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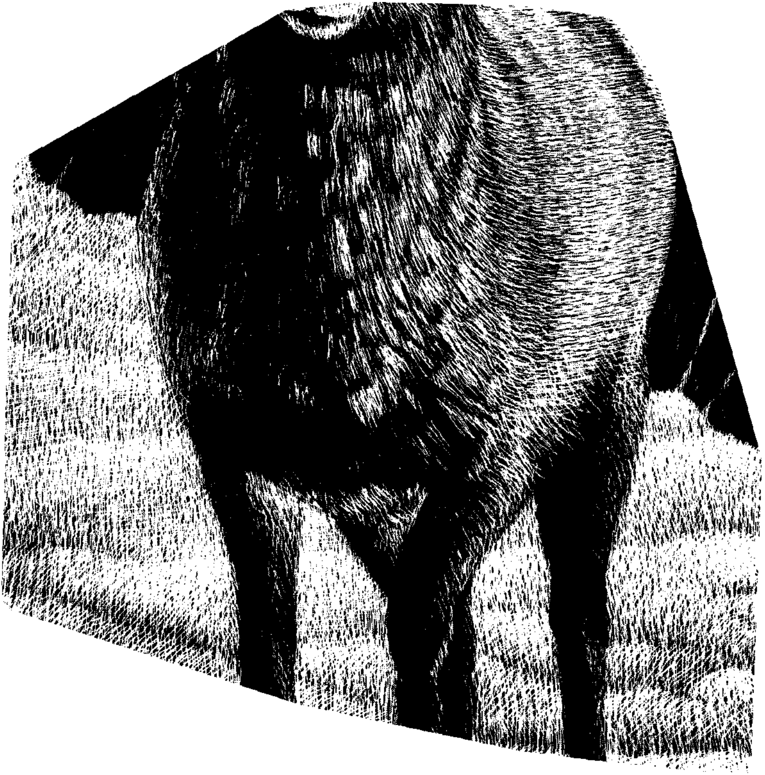
CONTENTS

Special Session 8. **Challenges in International Resource Conservation**

Special Session 11. **Introductions and Reintroductions of Wildlife Populations**



Opening Session.
Refining Priorities for Resource Management

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Cochair
WILLIAM A. MOLINI
President
International Association of Fish and Wildlife Agencies
Carson City, Nevada

Opening Remarks

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

Good morning. Welcome to the 55th North American Wildlife and Natural Resources Conference. We assemble here in the Mile High City to focus on "Resource Management for the '90s."

As we enter the final decade of the 1900s—gateway to the 21st century—the search for ecological soundness, sustainability and rational management in using the resource base is continuing and intensifying. Refinements call for (1) curtailing restoration costs and (2) perpetuating natural resource systems, values and uses. All of us here are involved one way or another in our daily domestic and professional activities. More members of society are expected to become involved, especially after the 20-year commemoration of the National Environmental Policy Act and Earth Day next month.

Among 10 new directions for the 1990s identified recently in *Megatrends 2000* (by John Naisbitt and Patricia Aburdene), 2 have implications for all of us: (1) the age of biology and (2) the triumph of the individual. The latter is the thread connecting all other trends. It is up to us as individuals to register lasting achievements, for—ultimately—it is values and priorities of individuals that drive social and environmental changes.

The vision for the future encompasses a transition to a more environmentally sensitive economy—a "kinder and gentler" economy, if you will—with sustainability interwoven with reasonable growth as the primary focus of economic policy making—internationally, nationally and locally. It is clear that some uses of the resource base must be realigned. Sustainability of natural resources must become a common cause.

Constructive refinements are being advanced to improve planning and managing natural resources. Among them, clean air, improved water quality and allocation, and wetland maintenance are receiving more attention. Response was prompt to Senator George Mitchell's call at the 1989 North American Wildlife and Natural Resources Conference to establish a pioneering, international partnership for migratory birds. The Congress and President Bush approved the North American Wetlands Conservation Act in nine months. Interior Secretary Lujan's recent appointment of the nine-member North American Wetlands Conservation Council helps assure management of key habitats needed to help restore migratory bird populations. More such timely conservation initiatives are needed to respond to President Bush's no-net-loss wetland policy.

Other helpful changes in policies and procedures are occurring. For example, economic calculation procedures are being reexamined. In the past, these procedures largely ignored environmental (societal) values. Thus, restoration costs (e.g., Superfund, pollution control, etc.) have continued to grow as the economy has expanded. But as the human population has increased and unbridled economic activities continued, the positive accomplishments of the economy have become less evident and the destructive consequences larger and more evident. Consequently, there is growing recognition of need for change.

This helpful development in thinking is well-documented in an important recent book, entitled *For the Common Good: Redirecting the Economy Toward Community, the Environment and a Sustainable Future* (by Herman E. Daly and John B. Cobb, Jr.). As one reviewer stated: "This painstakingly argued and deeply thoughtful book rescues traditional economics from its habitual abstraction and its fatal disregard for physical and biological principles. The result is an innovative, practical guide to our survival in the twenty-first century" (Ernest Callenbach).

All of us who must deal directly with the deleterious consequences of economic activities should become familiar with this publication and help accelerate constructive reform to promote ecological soundness and sustainability through integrated natural resource management. Therein lies hope for the future.

An important first step was taken in 1989 to realign economic accounting systems of the United Nations (P.L. 101–5). Past systems of measuring gross national product (GNP), for example, did not factor in the decline in national wealth when natural resources are degraded. From now on, degradation or depletion of natural resource assets must be recognized as a component of economic activities. No longer can one speak of economic growth without including environmental costs. This will correct the previous misrepresentation or false impression that a country can achieve economic progress by overexploiting its natural resource base. This connection is essential to place natural resource decisions and policies on a sound basis. It should lead to improved environmental and economic performances.

Other adjustments in how we carry out our activities are becoming more commonplace. Some—in managing water, forests and agricultural lands—illustrate their breadth and nature.

For most of U.S. history, water in rivers was used for navigation, transportation, disposal of wastes and, more recently, for a variety of out-of-channel uses. As the U.S. population approached and surpassed 200 million, people gradually came to recognize that unbridled uses of water in rivers are not in the best public interest.

Too many values—once assumed to be never-ending—have been degraded, and some have been lost.

Realization of pressing needs for managing river systems to perpetuate a variety of values and uses began to sharpen in the 1970s. Growing interest stimulated new advances in science to build a solid factual foundation on which to construct a stronger framework of legal authorities and administrative procedures for improving instream flows through integrated management of river systems. While some progress has been made to advance such management, additional efforts are needed to apply it in more western states with appropriation water law and adopt it for use in the eastern U.S. with its riparian water law.

All of these useful methods have become increasingly important in responding to (1) growing public concerns for ensuring habitats for wild living resources and (2) new legal demands for perpetuating habitats and values associated with stream channels and adjacent riparian areas, including wetlands. Experiences show traditional, but now inappropriate water-allocation systems can be adjusted to meet the government's public trust responsibilities for managing resources and to resolve water issues in the best public interest. More constructive efforts are needed to design and refine procedures that ensure instream flows and their inherent values, while accommodating compatible economic activities.

New cooperative agreements between the U.S. Fish and Wildlife Service, Army Corps of Engineers, Bureau of Reclamation, and National Association of Conservation Districts signal changes in vision and activities in water and land management affairs. Those agreements seek to accelerate implementation of the North American Waterfowl Management Plan. Parallel shifts are being proposed or are underway in Canada, through special efforts of its National Round Table on the Environment and the Economy, and the Canadian Wildlife Service's new emphasis on sustainable development.

As with water management, forest management continues to evolve as new knowledge from research and practical experience combines with public demands for change. Issues have emerged in the 191-million-acre National Forest System on such topics as biological diversity, habitat fragmentation, landscape linkages, old-growth forest stands and alternative silviculture systems. With thousands of appeals and lawsuits pending, the USDA Forest Service late in 1989 adopted innovative forest research and management concepts. "New Perspectives for Managing the National Forest System" will incorporate recent scientific knowledge with new societal objectives, such as maintaining diversity, into forest management plans and practices. This promises a more broadly acceptable approach to forestry that perpetuates ecological processes and values, while allowing compatible commodity activities.

Refined strategies include integrating reserved areas with commodity areas in landscape designs, using tree harvest/regeneration patch sizes (up to 200–300 acres or more) that provide a mix of interior forest and edge environments, and selecting tree-harvest systems that minimize habitat fragmentation. Implementing these "New Perspectives" concepts will demand considerable attention by the Forest Service and Congress in realigning timber-sale targets and placing national forest management on a more sound ecological and sustainable basis. Such refinements hold much promise for enhancing fish, wildlife, outdoor recreation and other benefits. Awaiting evaluation are local economic impacts of reducing timber sales and expanding recreational activities on 12 national forests in seven states (Colorado, Georgia, Illinois, Indiana, Ohio, Tennessee and Virginia).

Findings from such studies and others should permit designing better integrated resource management systems. Such systems, responsive to social needs and focused on resource sustainability, are essential to the Forest Service's mission of "caring for the land and serving people."

Similar more-sensitive systems are being developed and used in agricultural land uses. The Food Security (Farm) Act of 1985 (P.L. 99-198), for the first time in U.S. history, integrated a strong conservation dimension into federal farm support programs to correct excessive soil erosion, enhance water quality, restore wildlife and fish habitats, and place agricultural land use on a more sustainable basis. Unlike other federal agricultural efforts during the past 50 years, which have poured billions of dollars into marginally effective programs, the 1985 Farm Act uses a new approach linking stewardship of land, water and wild living resources with landowner and land-operator eligibility for federal farm benefits. Six major programs were created or affected: conservation reserve, acreage reduction, sodbuster, conservation compliance, swampbuster and conservation easements.

Unique opportunities exist for using 50-year or longer conservation easements to assist debt-burdened farmers by allowing them to cancel a portion of their delinquent debts. Rather than being a federal "give-away" program, conservation easements are a long-term public investment to maintain and sustain valuable public values and resources, such as wetlands. Simultaneously, conservation easements help farmers remain financially solvent, keep their farms under private ownership and management, and continue to earn income from compatible agricultural production. Swapping debt for conservation is being used internationally. A smooth-flowing process is needed in the Farmer's Home Administration (FmHA) and other U.S. loan agencies (Resolution Trust Corporation and Federal Deposit Insurance Corporation). Hopefully, FmHA will respond promptly and positively to the reform called for recently by Senator Robert Dole and others.

Proposals are now being evaluated by the Congress as it prepared new legislation to replace the expiring 1985 Farm Act. Specific recommendations have been offered to help remove costly inconsistencies in agricultural programs, to continue and improve the pioneering provisions in the 1985 Act, and to incorporate new features that put agricultural land and water uses on a more sustainable basis. Your participation is essential to ensure needed improvements in the 1990 Farm Bill. Integrated management, as advanced through recent legislation in California, Iowa and Minnesota, should be the cornerstone of the 1990 Farm Bill.

Polls demonstrate clearly that citizens want substantially better management of the resource base. Responding to those demands requires well-designed educational programs and effective public service at all levels. A new statement of national education goals issued recently by President Bush and the National Governors' Association emphasizes that student proficiency must be upgraded, especially in math and science. Structural improvements in our schools and society are needed to ensure a thread of continuity for ecological soundness among generations and for providing knowledgeable individuals and partners to carry out enlightened, integrated resource management.

The most widely used environmental education program in the world is PROJECT WILD, reaching more than 11 million students each year. Sponsors currently using the program include 47 states, 10 Canadian provinces and territories, and 6 organizations. Although these figures are impressive, only a small percentage of classroom teachers and students is being reached. A greater outreach to more schools, teachers and students is essential as the age of biology and the individual gain importance in the 1990s and the next century. Your help in ensuring use of PROJECT WILD in your states, provinces and schools is needed to strengthen this critical partnership effort. Increased educational efforts are needed to promote and ensure application of integrated management of waters, lands, forests, ranges and other resources.

Just as pressing as educational reform is the need to rebuild capabilities of government public services. Need for innovative, effective public services is expanding, not declining. Nevertheless, a 1989 General Accounting Office report stated that the U.S. federal public service is not what it needs to be. How well essential public services are carried out affects the pocketbook and quality of life for all of us.

Regrettably, you may find, instead of well-qualified incumbents in key positions, some individuals with responsibilities for which their personal knowledge and experience are weak or lacking. Similarly, their views may be biased against moving needed resource management programs forward. These situations are causing grave concerns and inefficiencies in public services and programs badly needed to ensure sustained uses of the resource base.

Listen carefully to the findings and heralded recommendations of the National Commission on Public Service to be presented later this morning. Needed improvements in government recruitment, employment and services will be identified. Urge President Bush and the Congress to implement those timely recommendations immediately. They can help relieve the obvious strain between many political appointees and career civil service employees, and strengthen needed public services.

Participate in as many sessions of this Conference as you can. They are designed to provide insights for maintaining and managing natural resources on a sustainable, multiple-benefit basis. And when you get home, become involved in advancing such essential rational management. That will put you among the trendsetters for the 1990s and the 21st century.

New Conservation Initiatives Toward Sustainability

U.S. Senator Robert W. Kasten, Jr.
Washington, D.C.

We're here to talk about conservation. And I think that, today, we have a greater opportunity than we have ever had before to restore environmental sanity to our planet.

People all over the world are recognizing that we're all in this together—that we have to cooperate to make the world a safe and healthy place. People are willing to make sacrifices for liberty—and for the global environment in which they enjoy that liberty.

The human race has woken up to the environmental consequences of its actions. And we're turning our concern into political action. I see this in my work on the Senate Foreign Operations Subcommittee—concerned citizens appeal to us constantly, insisting that *the U.S. must not use its foreign lending policies to promote environmentally destructive development.*

When we support economic development abroad, we must be aware of the social and environmental consequences, both costs and benefits. We cannot afford to keep on the blinders of outdated economic development theories that fail to take into account the environmental costs that will be borne by future generations.

That's just one example of popular concern. Our international efforts to preserve endangered species are another case in point. Public pressure helped us ban the importation of ivory—and this policy is just now beginning to make a positive difference in elephant populations. Let's keep the heat on.

There are countless examples of how environmental activism has helped us follow the right path. A little later on, I'd like to discuss an initiative of my own that I think would help bring American agriculture in line with sound and sustainable conservation practices—an initiative that will require the support of groups like this one in order to succeed.

The concept of *sustainability* has come of age, not only for natural resources such as soil, water and wildlife, but for social and economic factors as well. We all know that perpetual growth is neither possible nor desirable. In all areas of social, economic and environmental policy, we must seek goals that will lead to optimum and sustainable results, *not maximum production.*

I would like to expand on this lineage between economics and the environment, by examining for a few minutes the changing role of conservation in American agriculture. The single most important conservation measure Congress will act on this year will be the Conservation Title of the Farm Bill.

I know that I'm preaching to the choir when I say that American wildlife is dependent on American agricultural practices. Most of the wildlife in our nation lives, breeds, and dies on private agricultural lands. At an even more basic level, the health of both agriculture and wildlife depends in the long run on soil and water. Where the land or water is poisoned, where ground water or topsoil is being mined, where soil is being worn out, where vegetation is stripped, *neither wildlife nor* *agricultural production can enjoy a secure future*. This was the idea that prompted the language I wrote into the Conservation Title of the 1985 Farm Bill.

Our rural social structure, our rural economy and our rural environment are tightly woven together. When we change one, we change them all. So when we *do* make a change, *it has to be a prudent one*. I would argue that the Conservation Title of the 1985 Farm Bill was an example of prudent and far-sighted change.

The 1985 Farm Bill was landmark legislation—it linked together, for the very first time, public financing of agriculture with conservation requirements. The highly erodible and wetlands conservation provisions—known as sodbuster and swampbuster—required producers who participate in most Federal farm programs to refrain from converting erodible lands and wetlands to crop production.

Accompanying this prohibition was an incentive, the Conservation Reserve Program (CRP), by which producers were rewarded for retiring cropland and establishing permanent cover for a 10-year contract period. Another provision was a domestic version of debt-for-nature swaps—providing relief on farm debt in exchange for conservation easements for environmentally sensitive lands. The 1985 Farm Bill is a good foundation to build on—and that's what we have to do with the 1990 Farm Bill. We need to build on these forward-looking concepts, and make some course corrections to improve the working of the 1985 provisions. Then we can take further steps to ensure progressive and responsible stewardship of our precious soil, water, wetland and wildlife resources.

When I get back to Washington, I'm going to introduce legislation that will amend and expand the Conservation Title of the Food Security Act to build on our 1985 base. This legislation will recognize that *farmers* are the key stewards of our nation's bounty, and that both agriculture and wildlife depend on the effective conservation of soil and water. No issue could be more important to wildlife, or to the food security of America.

My bill—the Farm Stewardship Act of 1990—would improve the stewardship of natural resources on our private agricultural lands. We can only achieve this goal by providing an economic climate that encourages and rewards good stewardship, and by providing the solid information and assistance farmers need if they're going to make sound stewardship decisions about their soil, water, wetlands and wildlife.

The bill seeks to build some fairness into how Federal agriculture dollars are spent—*rewarding farmers who conserve and punishing those who waste*. The bill is a combination of carrot and stick approaches to conservation. There are incentives *for* intelligent conservation practices, and prohibitions *against* poor practices. As a package, it provides a real step forward in farm conservation—and I believe it will earn the support of both agriculture and conservation interests.

Let me outline the major provisions of my approach. Title I, Soil Conservation, would protect the producer's crop base on expiring Conservation Reserve Program contracts. It would establish national soil erosion goals approaching "T by 2000"—that is, by the year 2000, soil erosion rates must not exceed soil loss tolerance rates—and extend CRP for highly erodible land. Beginning in 1995, highly erodible cropland coming out of CRP that cannot meet the "T" standard would be eligible for a new "Environmental Stewardship Program" or ESP.

The Title on Water Conservation provides that farm conservation plans will specify best management practices or other measures to ensure that farm operations are consistent with Federal and state water quality standards, and require that these plans must be applied where standards are being violated. It seems unwise, from both policy and fiscal standpoints, to establish a major separate federal water quality program under USDA when the states already operate a federally-funded water quality program.

A second feature of the water title would make cropland eligible for the ESP if it is an identified groundwater recharge area, if it has features like sinkholes, or if agricultural production on it has a high potential to contaminate surface or ground water.

My bill proposed two crucial course corrections for the swampbuster wetlands conservation program. I'm sure you're all aware that swampbuster has not been implemented in a way that has served wetlands conservation or agriculture very well. According to data collected by the Soil Conservation Service, over 77,000 acres on over 3,200 individual wetlands have been converted since 1985, on only 25 percent producers' farms that have had wetlands determinations made. If we extrapolate this number to a full 100 percent of producers' farms, it would mean the destruction of *over 300,000 acres of wetlands*.

Yet, according to a National Wildlife Federation study, only 26 producers have actually had federal program monies withheld. While I don't relish the prospect of farmers losing their Federal benefits, I nonetheless believe that we have to toughen the enforcement of this provision. The numbers simply don't make sense—agricultural wetlands conversion is continuing, and enforcement of swampbuster has apparently not yet been directed at the individuals responsible.

I advocate two linked proposals to improve swampbuster. First, violation of swampbuster should be effective upon conversion of the wetland, not upon planting of an agricultural commodity. In addition, farmers who violate swampbuster should forfeit their claim to USDA technical assistance and loans made, insured, or guaranteed by the Federal Government. Second, I propose a reduced penalty for first-time violators—*provided* that the converted wetland is restored or its conversion mitigated through an agreement between the Soil Conservation Service, the Fish and Wildlife Service, and the producer. The producer would have one year to accomplish the restoration—otherwise, the *full penalty* would be imposed. Under my plan, the reduced penalty would be a one-time qualified amnesty for violators. Our purpose should not be to punish, but to encourage compliance and the restoration of converted wetlands.

In order to provide farmers an option to farming wetlands, I am proposing that cropped wetlands, formerly cropped wetlands, and wetlands with a high potential for conversions be eligible for the Environmental Stewardship Program (ESP).

The bill would encourage the use of wetland and flood plain easements under the authority of the Small Watershed and Flood Protection Act. It would prohibit USDA from using Federal funds for conversion of wetlands. Such a provision will remove some of the mixed signals the Federal Government is sending on wetland conservation.

The Wildlife Title of my bill, which some have called "nest buster," calls for the designation of the same land each year for set-aside land, and for the establishment of cover on *all* set-aside acreage. Set-aside acreage in perennial cover would be considered as planted to the program crop for deficiency payment purposes as long as the cover is maintained. *This provision would turn the millions of acres of set-aside acreage into productive wildlife habitat.*

It would also reduce erosion, improve water quality, and provide a forage reserve for use in emergency situations. Haying or grazing would be limited to certain periods in order to minimize negative effects on nesting. Finally, important habitat for threatened and endangered species, migratory birds and other key species would be eligible for the ESP.

The centerpiece of my proposal is the Environmental Stewardship Program, a concept advocated by many of you here and by many organizations you represent and work with. The ESP would be a voluntary program to protect permanently, through conservation easements, fragile resources including soil, water, wetlands and wildlife. Unlike the CRP and other term set-aside programs, the ESP would target those fragile resources where it will *never* be in the interest of the nation to continue cropping.

A key feature of the ESP is allowing the landowner to make economic uses of the conservation area that are compatible with protecting it—like hunting leases, periodic hay cutting, or managed timber harvest. Compatible economic uses would be controlled through agreements between the U.S. Secretary of Agriculture, the easement manager and the landowner. The bill encourages states and landowners to get involved in management of the easement areas.

In order to provide better information to all interested farmers so that they can make better farm decisions, I am proposing that whole-farm conservation plans be prepared by the USDA in cooperation with the landowner. These plans will address key resources on the farm and provide the basis for more wholistic stewardship.

The ''debt for nature'' title builds on the 1985 Act to improve the ability of farmers to obtain debt relief in exchange for the granting of conservation easements. I believe that this option should be available to every financially troubled farmer early in the process of restructuring his farm debt. This approach provides the double benefit of keeping farmers on the farm and protecting fragile resources. This title also calls for protecting resources held in the Farmers Home Administration inventory, and for holding wetlands and other fragile areas as collateral to secure direct federally insured or guaranteed loans.

I think this bill is the essential next step in the struggle to preserve our natural heritage. Our country has been blessed with resources—it's up to us to be sensible in protecting them. As we approach Earth Day 1990—a truly global expression of our common commitment to environmental health—let us begin our concern and our activism right here at home. Together, we can make this conservation bill the law of the land, build a safe and healthy future for America and set a responsible example for the whole world.

Rebuilding the Public Service for Natural Resources Management

L. Bruce Laingen
Executive Director
National Commission on the Public Service
Washington, D.C.

The Volcker Commission is a private, non-profit group of 37 prominent Americans who came together out of a shared concern that the Federal Government faced the risk of an erosion of talent in the public service of government—a group that shares a consensus that if government is to do its job and do it well, it needs quality people, all up and down the line. In other words, quality management of the national agenda. I assume it is because you too share that concern that I was included on your already crowded agenda: "Resource Management for the '90s."

Management of course is many things—but the bottom line in management is always people. People, men and women, doing their jobs, and hopefully doing them *well*, with the maximum of *efficiency*, of *enthusiasm*, of *commitment*, and—not least—*integrity*. In your field and in others, the nation deserves no less, particularly at a time when budget resources are short. And at a time when change, in both the international and domestic arena, *is the name of the game*.

There's an old expression that puts it well: an effective manager cannot be simply an organizer of the *status quo*. He must also be an organizer of *considered change*.

Your theme, "Resource Management for the '90's" is understandably the task of many people, at many levels, in both the public and private sectors, in academia, and across our international borders. But surely prominent among them is the work force of government—at the Federal and the state and local levels.

The Volcker Commission's focus has been primarily at the Federal level. Yet we are fully aware that most of our conclusions apply equally at the state and local level, and we are encouraged that several of the states are now considering commissions similar to ours to examine problems at that level. For it has always been the case—and increasingly so today—that it is the state and local levels of government that are the most directly responsible for providing the majority of public services essential for economic viability and a high quality of life for our citizens.

The Volcker Commission completed an action oriented report a year ago and presented it to the President and Congress. Since then we have been working to encourage both branches of government to translate our recommendations into legislative action. We are also enlisting the support of a broad range of public interest groups, some of whom are represented in this audience today, in a coordinated program of action.

Our report included 45 recommendations for action, the details of which I need not mention this morning, but let me briefly summarize some of our principal goals:

1. We need to rebuild the public's *trust* in its public service work force, starting with leadership in the Oval Office and extending throughout government. To quote from one of those who studied this issue: "The only way the public's perception of the public service will improve is if the President takes the lead."

2. We need to improve the Presidential appointments process, to do a better job of getting the best qualified people into the non-career jobs. As one of our members said, ". . . we want standards for political appointees that ensure *capability* as well as *compatibility*."
3. We need to make more room near the top for *career* executives in public service; as the same we need to strengthen the political/career executive partnership.
4. We need, to the greatest degree practicable, decentralize government management at all levels.
5. And, perhaps most important of all, we need to give more thought to the *future*—rebuilding student interest in, not just public service careers, but also in *community service*, and in the need for *active acceptance of citizenship responsibilities*.
6. Thus, the Commission urged a new review of *school curricula* dealing with *civics*, and starting early, in our *primary* and *secondary* schools, so that our young people—whether they plan government careers or not—learn at the early perception forming age *what government does*, how government *serves* them and yes, how it does not, and what their civic responsibilities are in this increasingly crowded world of ours. The way in which many of you, not least through 4-H clubs and junior environmental groups, are so well positioned to help achieve that bottom line—*participatory citizenship*.
7. With the help of leadership at all levels—and with the help of the media—we need to open new channels of communication about the opportunities, the challenges, and—in our view—the rewards of a public service career.
8. We must increase the representation of *minorities* in public service careers.
9. We must provide competitive pay, in return for which, we must demand *competitive performance* . . . something everyone who has ever managed a public agency would say "Amen" to.
10. And, of course, we need to increase government productivity on the front line—in other words, service delivery, of a quality and of an effectiveness that helps convince the public out there, to borrow a term from the computer age, that government is "user friendly."

All of this, you are probably thinking, sounds like a lot of pious platitudes. Hardened bureaucrats among you are saying to yourselves that you've heard all this before. True, change in this area doesn't come fast. For that reason we made it clear that our report was little more than a plan, an agenda, that needed national debate and attention.

But we are nonetheless modestly optimistic, on several counts: The Volcker Commission's membership, prestigious as it is, carries some special clout. A new President, George Bush, speaks of public service as an honored profession. That helps, and helps a lot. Congress, including hopefully Senator Kasten here this morning, is considering supportive action. And, not least, the cooperative support of those numerous public interest groups out there; we seek to build a coalition of support from those who share our concern; from Common Cause to the Sierra Club, from your Wildlife Management Institute to the 4-H Clubs, from the Park Service to the scouting movement. We need that; the nation needs it.

Some fifty years ago, in 1937, another commission, the Brownlow Commission, appointed by President Roosevelt to study and make recommendations on the performance of the Executive Branch, opened its report with these words: "The Government of the United States is the largest and most difficult task undertaken by the American people, and at the same time, the most important and the noblest."

That observation is certainly no less true today. The American people's "*largest* task"? Whatever the merit or impact of such policies as "privatization" or "contracting-out," the civilian work force of government remains the nation's *largest* undertaking.

The nation's "*most difficult task*"? Surely that is even more true than it was 50 years ago, given our *growing population* and *ethnic diversity*, and such problems as *pollution, drugs, acid rain, AIDS*, and other challenges that were scarcely even known about, if at all, in 1938.

The most "*important* task"? Surely a nation's collective commitment to a common good, the well-being of all of its citizens (which is what government is all about), must be, by definition, our most important undertaking.

And the "*noblest* task" undertaken by the American people? Well, when government ceases to be seen as that, both it and its work force will have lost the respect and the support that any government must have to function, above all, in a democracy such as ours.

I have no doubt that the many organizations that make up this audience, dedicated as all of you are to preserving the natural resources and wildlife with which our country is so abundantly blessed, care deeply about those tasks. I salute you for the way you work to translate those concerns into action.

Canada's New Soil Conservation Initiative

Harry M. Hill
Director General
Prairie Farm Rehabilitation Administration
Agriculture Canada
Regina, Saskatchewan

This talk is about the Canadian National Soil Conservation Program and its relation to wildlife conservation. As in the USA, agriculture is quite different in different parts of our country. The National Soil Conservation Program is being adapted to each region of Canada, consequently, the program has different elements in different provinces. My talk will concentrate on the prairies—that is the agricultural areas of Manitoba, Saskatchewan, Alberta and parts of British Columbia that lie to the North of the Dakotas and Montana. Soil conservation activities in other parts of Canada also have wildlife interfaces, however, I will leave discussion of these to others at another time.

Within this context, I will briefly discuss Canadian prairie agriculture and its challenges, sustainable agriculture concepts, our Minister's Policy Review, the National Soil Conservation Program and agriculture/wildlife compatibility.

Canadian Prairie Agriculture

In a sense the future of prairie agriculture looks good. The prairies produce food for export and world demand for food continues to grow. However, world food markets are uncertain and with the international subsidy wars, mainly between the common market and the USA, market prices for prairie agriculture products are affected adversely. The prairie agriculture economy is suffering. It is within this context that prairie farmers are being asked to become more active in conserving or enhancing the environmental resources that they use or impact. The challenge to both the agriculture and wildlife sectors is to identify and take advantage of opportunities as they arise.

There are two interconnected agricultural policy initiatives underway that will likely affect prairie agriculture and its relationship to the wildlife sector. These are the worldwide initiatives toward sustainable development and the agriculture policy review initiated by the federal and provincial ministers of agriculture.

Sustainable Agriculture

There has been considerable discussion about sustainable development since Canada adopted international sustainability concepts. These apply to agriculture as well as to other economic sectors. A federal-provincial working group has proposed a definition: "Sustainable agri-food systems are those that are economically viable, and meet society's need for safe and nutritious food, while conserving or enhancing Canada's natural resources and the quality of the environment for future generations."

This definition suggests four focal points of sustainable agriculture:

1. Consumer based (food supply and quality)

2. Commodity/farmer based (farm economic viability)
3. Community based (rural communities)
4. Local ecosystem/farmer based (environmental resources)

From the consumers' point of view, there is a focus on food supply and quality. Farmer concerns focus on economic viability, which is one key to sustainable agriculture. This focus is linked to efficient production systems, and insurance schemes. Rural community sustainability issues focus on communities. The continued existence of rural communities is vital to the rural quality of life, access to services and farm sector stability. Environmental issues focus on natural resources. These issues require locally-specific actions at the farm level to conserve resources and protect the environment.

All points of view are important. A suitable agri-food system includes requirements of the consumer, the farmer, the communities and the environment. It is within this context that we are dealing with agriculture environment sustainability.

Policy Review

Reform of Canadian agriculture policy was discussed at a national conference last December. Discussion centered around the desire to make Canadian agriculture more market responsive, self reliant and environmentally sustainable while taking more advantage of regional diversity.

The issue of most concern to this audience is most likely the desire for increased environmental sustainability. This means conservation or enhancement of the natural resources the agri-food sector uses or impacts. We will need to adopt technology and practices that encourage soil and water conservation and the regeneration and preservation of wildlife habitats. Also, it will be important to preserve the genetic diversity of our crops and livestock. It also means government policies and programs must be designed so they do not contribute to the degradation of our environment.

This policy review is in full swing. The challenge is to identify and pursue opportunities that will make our agricultural industry more durable and viable than ever. How can we develop stronger communities and family farm enterprises, and enhance our environment and our rural way of life?

With this backdrop I will discuss some conservation programs and some agriculture/ wildlife interfaces.

Land Resource Conservation

Governments have been in the land reclamation and conservation business since the thirties. The Federal Government established the Prairie Farm Rehabilitation Administration (called PFRA) in 1935 to deal with the drought and soil drifting areas of the prairie provinces. Community pastures and agriculture improvement associations were major programs aimed at the degradation issues of the thirties. The agricultural improvement associations were groups of farmers working together to address soil degradation concerns. The community pasture program remains as valid today as fifty years ago—the program keeps marginal land in grass. Today, we have embarked upon the eighties and nineties version. It is called the National Soil Conservation Program (NSCP).

Canada's National Soil Conservation Program was announced in December 1987, following approval of the National Agriculture Strategy by first ministers. The strategy spells out the principles for cooperative federal-provincial action to address soil degradation issues across Canada. The National Soil Conservation Program provides $75 million in federal funding over three years, distributed on the basis of the degree of soil degradation in each province. Provinces have matched the funding, under the umbrella of long-term soil conservation accords.

I will discuss the elements of the National Soil Conservation Program that are now being put in place in the three prairie provinces. As already indicated, program elements vary province by province.

The Canada-Saskatchewan Agreement on Soil Conservation provides $54 million over three years to Saskatchewan producers. In cooperation with Ducks Unlimited and the Saskatchewan Soil Conservation Association, the agreement provides support in on-farm conservation, land-use adjustment, awareness and education, soil inventory and monitoring, and research and development.

Land-use adjustment is encouraged through the Permanent Cover Program. Under long term contracts, producers are provided with financial assistance to establish permanent forage cover on lands not suitable for annual crop production. The Save Our Soils Program will be provided through the provincial system of Agriculture, Development and Diversification (ADD) Boards. Each ADD Board is producer based, with two farmer representatives from each municipality within its boundaries. ADD Boards have developed conservation plans, in consultation with a regional team of agriculture and wildlife specialists.

Through the ADD Boards, producers may obtain technical advice and specialized soil conservation equipment. ADD Boards will assist producers to adopt new soil conservation methods such as field shelterbelts and new crop residue management systems, and implement contour and strip cropping, establish forages on erodible or saline land and extend crop rotations. The ADD Boards will also be promoting the establishment of new wildlife habitat through multi-row field shelterbelts, block plantings and abandoned farmyard plantings. Producers establishing these types of plantings will be eligible for grants for planting and maintenance. Technical assistance for designing these plantings will be provided by a wildlife biologist.

In addition to these programs, producers can receive support to establish and improve wildlife habitat through such initiatives as the Prairie Care Program implemented through Ducks Unlimited Canada.

Other components of the agreement will allow for the completion of a detailed soil survey, and the enhancement of soils research. Under the Alberta program Agricultural Service Boards, which are similar to Saskatchewan's ADD Boards, are the main vehicles for the delivery of on-farm conservation programs. The program mix in Alberta is similar to the Saskatchewan program. A special effort will be made to review government programs and policies that may negatively influence the adoption of soil conservation practices.

As in the other provinces, producer organizations in Manitoba will develop a work plan, and provide technical advice, access to conservation equipment and financial assistance to local farmers. In Manitoba, farmers will be expected to complete a conservation plan before receiving assistance. An alternate land use program is being developed in consultation with wildlife agencies.

One of the unique aspects of these implementation plans for us is the use of regional conservation advisory teams. These teams include wildlife as well as agriculture specialists. We hope to develop on-farm activities that show more compatibility between wildlife and agriculture. In the past the two groups have mostly worked independently and often at odds.

Increased Agriculture/Environment Compatibility

We are just beginning to realize how agriculture can be compatible with the good management of environmental resources. Although we are just beginning the search for agriculture/environment compatibility in earnest, the issues will probably fall into three categories. There will be situations where agriculture practices can easily be compatible with the environmental resources and vice versa. In these cases the challenge is to identify the areas of potential compatibility and exploit them. There will likely be situations where agriculture and the desired management of environmental resources are clearly incompatible. In these cases the challenge will be to make rational tradeoffs. And finally, there will be cases where compromise will be required to address both objectives in some optimum fashion. I will address some of the situations where I feel compatibility can be possible.

I. Establishment of Improved Forage Stands

The National Soil Conservation Program promotes the establishment of perennial forages. Also the Permanent Cover program promotes the conversion of larger units of low quality cultivated land to forage and/or treed areas. Other soil conservation activities promote the establishment of forages in grassed waterways and saline areas. Benefits for agriculture are increased through provision of high quality forage, while wildlife benefits increase from the provision of more permanent habitat. To further increase advantages to wildlife, late haying may be implemented under contract between wildlife organizations and the farmer.

II. Maintenance and Enhancement of Native Stands

Range managers strive to develop management plans that maximize the use of forage resources for livestock production while maintaining stocking rates that ensure the long-term vitality of the native grass and tame species. In turn, wildlife benefits through provision of sound nutrition and cover.

III. Provision of Nesting Cover

The prairie provinces support abundant wildlife populations and almost half the continent's waterfowl breed in the region. The North American Waterfowl Management Plan is aimed at enhancing waterfowl production.

Provision of nesting cover during the critical spring and early summer period can be integrated into farming systems. In particular, reduced tillage systems and production of winter grains are being promoted under the National Soil Conservation Program. These practices are aimed at maintaining adequate crop residue throughout the year, thus preventing damage from both forms of erosion. Chemical applications can be applied in fall and spring as a substitute to the conventional alternative of several tillage passes between harvest and seeding. A change of tillage equipment for summer fallow from the cultivator to a stubble mulcher will still adequately control weed populations while retaining surface trash where it can provide erosion protection. Substitution of two or three applications of herbicides for tillage also provides a reasonable alternative during the summer fallow year for maintaining trash cover. These practices can address a wildlife goal of undisturbed spring and early summer nesting habitat. In a hay production system, delaying the hay cut until the middle of July will also produce this desired result. Ducks Unlimited's Prairie Care Program is utilizing this and several other ideas to develop nesting habitat.

In Alberta, nesting islands have been constructed in the middle of large dugouts. These water sources also act as a focal point for rotational grazing systems by providing a permanent water source for a number of pastures at a time. PFRA and Ducks Unlimited are discussing pilot projects to enhance the value of dugouts to waterfowl.

IV. Cover and Nutrition

Presently, seedlings are provided for thousands of miles of shelterbelts to protect farmland from wind erosion. Multi-use Field Shelterbelts that incorporate fruit bearing shrub species along with the usual tree species are promoted. These multi-use shelterbelts provide wind erosion protection and trap snow. They also provide wildlife cover and dense nesting protection, and make available nutritious fruits during the critical winter period when energy demand is highest for wildlife. Each year these plantings improve wildlife habitats on thousands of square miles of farm land.

Development of wildlife habitat from existing patches of trees is also possible by expanding bluffs within fields or modifying abandoned farmyards to create more habitat diversity and provide protection. Common species that are available to local farmers are choke cherry, sea-buckthorn, dogwood, rose and Russian olive.

V. Management of Water

Waste Water from irrigation can be utilized to develop marshland habitat and improve forage production on native stands for increased grazing capacity for livestock and wildlife species. The Eastern Irrigation District in Alberta is developing these opportunities at present in conjunction with wildlife organizations.

Wrap-up

In Canada we are exploring concepts of agriculture and environmental sustainability within the context of a major policy review. At the same time, attempts are being made to combine sound stewardship of the soil resource with management of wildlife habitat through the many on-farm activities currently being implemented through National Soil Conservation Program, Prairie Care and other Canadian initiatives. We feel that both agriculture and wildlife production objectives can be accommodated. Current initiatives have created an active dialogue and cooperation among the farmers and the agriculture and wildlife specialists. We hope to identify other on-farm activities that will positively impact both agricultural and wildlife production. All levels of government in concert with private organizations are striving towards a "win/win" scenario for the agricultural wildlife interaction throughout Canada.

Challenges for Fish, Wildlife and Parks

Constance B. Harriman
Assistant Secretary
U.S. Department of the Interior
Washington, D.C.

It is a special honor to be with you today. The North American offers a much heralded opportunity for wildlife experts and conservation leaders, throughout the continent, to address the major resource issues of the day.

I want you to know that I have been in office for only seven months. I am still learning many of the details and complexities of biological and natural resource management. I am also still learning the ins and outs of policy and budget formulation at the Department of the Interior. But, I am in there swinging. Those of you who are familiar with issues, such as elephant and chimpanzee protection under the Endangered Species Act and management of off-road vehicles use on Cape Cod National Seashore, can attest to that.

I think many of you who have had continuing contact with the Secretary or with me will concede that there is a new and refreshing breeze blowing at Interior. You might characterize it as a mild zephyr, in fact. I know that my door has been open to everyone of you. And, I have over the last seven months tried to meet with as many conservation organizations and work with as many concerned senators and congressmen as is humanly possible.

I feel today, as I think you do, a sense of urgency and expectation in the air. This conference is a powerful reminder that we embark on a new decade and face a new century—a world with complex challenges that call for immediate and aggressive action. Today, I will discuss some of the challenges confronting the Fish and Wildlife Service in the coming decade of the 1990s, and beyond. It is a selective list. They are merely some of the challenges that are of particular interest to me, as Assistant Secretary for Fish and Wildlife and Parks.

A key challenge of the 1990s will be environmental education. Education has always been an essential part of resource conservation. But as we approach the 21st century, education has become critically important. More and more Americans are city dwellers. More and more Americans turn to television and radio for information about the world they live in. The fathers and grandfathers of our children developed an abiding love of the land and nature from uninterrupted hours of hunting and fishing. Our children are now planted firmly in front of the television set. Chances are they neither hunt nor fish and never will. Meanwhile, as our exposure to the outdoors shrinks and we become increasingly ignorant about wildlife and other natural resources, the environmental issues confronting us swell in numbers, size and seriousness. Time is of the essence! If we want the general public to possess a conservation and environmental ethic and to be capable of informed judgment about environmental issues, the Fish and Wildlife Service should shoulder more of the responsibility for providing environmental education.

The Fish and Wildlife Service has all the right resources—visitor centers—throughout our National Wildlife Refuge System, national fish hatcheries, research units, education cooperative units in 39 universities and thousands of field units, all with resources and staff to provide educational opportunities to people throughout America. It is most appropriate and long overdue.

I, for one, am targeting the school children of our nation. Today, a handful of national wildlife refuges—among them San Francisco Bay National Wildlife Refuge in California, Minnesota Valley National Wildlife Refuge near Minneapolis, Minnesota, and Ding Darling National Wildlife Refuge in Florida—have well designed and effective environmental education courses for school children whose teachers arrange in advance to bring them to the refuges. Just last week, I spent a day at the San Francisco Bay Refuge. It is the first urban national wildlife refuge. It is also the largest.

Last year, 30,000 school children came to the refuge to learn about wetlands, ecosystems, endangered species and habitat. Their teachers taught them—based on materials and training provided by Fish and Wildlife Service staff. The same teachers keep coming back. Last year, the San Francisco Bay Refuge turned away 30,000 school children—as many as it took in.

I would like to see similar environmental education courses offered at the new visitor's center at Patuxent National Wildlife Refuge, the doorstep of our nation's capitol; also at the visitor's center at the Rachel Carson National Wildlife Refuge in Maine—one of our most highly visited refuges and a stone's throw from Kennebunkport; also at the new national center for education and training to be built at Harpers Ferry, West Virginia.

This week, I am convening a task force of Fish and Wildlife Service professionals to start to tackle the challenge of establishing environmental education courses and programs throughout our National Wildlife Refuge System. Tune in at the next conference to see how we have done!

A second major challenge in the 1990s and beyond is wetlands protection; more specifically, the implementation of policies and programs to make good on the President's pledge of "No Net Loss of Wetlands." Director Turner and the Fish and Wildlife Service have prepared a comprehensive wetlands protection plan for Service programs. It is currently being reviewed in the Department of Interior. This Fish and Wildlife Service Action Plan will set the stage for Service activities in wetlands protection, restoration and management, as well as in research and education.

May 1990 will mark the fourth anniversary of the North American Waterfowl Management Plan. Joint ventures under the Plan—joint ventures in which many of you here today played leading roles—have led to significant achievements. Yet, opportunities for wetlands protection still abound throughout North America.

Last year, with your help, Congress passed and the President signed the North American Wetlands Conservation Act. The Act serves to implement the North American Waterfowl Management Plan. In addition, the Act provides major incentives for federal/state/and private partnerships to further wetlands protection in Canada, Mexico and the United States.

Secretary Lujan recently announced the nine members of the Council authorized under the North American Wetlands Conservation Act. With this star quality council in place and with the Bush Administration's budget request for $25 million in fiscal year 1991 for wetlands acquisition, restoration and protection, let us seize the welcome opportunity before us to make major strides in wetlands conservation throughout North America.

A third challenge before us lies in the international arena. We must seek out and create opportunities to work cooperatively with other countries—to meet the looming challenges of global climate change, rain forest destruction, wildlife loss, habitat depletion, wetlands loss and runaway illegal wildlife trade.

- The Bilateral Agreement between the United States and Russia—signed by Nixon and Brezhnov in the 1970s—now contains the most comprehensive list ever of proposed joint activities between the two superpowers: polar bear research, migratory bird work, research on pollution in the Bering Sea—to name just a few.
- Three months from now, the Fish and Wildlife Service will host a joint American/Russian conference in Virginia. More than 40 Soviet environmental managers and administrators will meet with Fish and Wildlife Service professionals to explore ways our two nations can work together to solve wildlife and environmental issues in the Arctic.
- Next month, Fish and Wildlife Service representatives, Director Turner, and I will meet in Mexico with our counterparts to discuss strategies for wetlands protection.

The bilateral agreements, research and exchange protocols, and conferences that the Fish and Wildlife Service has participated in to date should be expanded and duplicated to include more countries and more issues. Eastern Europe now embodies especially fertile ground for international cooperative efforts to address environmental problems of monumental proportions. I recently gave the Fish and Wildlife Service a big green light to develop initiatives for Eastern Europe.

A fourth challenge in the 1900s is restoration of our Great Lakes fisheries. As a Presidential appointee on the Great Lakes Fisheries Commission—an international Commission with representatives from Canada and the United States—I am alarmed at the continuing decline of our fisheries resources. The threats that place our fisheries in peril endure. And they multiply. First, it was the sea lamprey. Now, it is the sea lamprey and contaminants and the zebra mussel. A recent article in *The Washington Post* suggests that the zebra mussel is swiftly becoming one of the major natural disasters of the Great Lakes. If we are to preserve commercial and recreational fishing and tourism in the eight states bordering the Great Lakes, we must take immediate action. And, we must act cooperatively. The Fish and Wildlife Service should work with state fish and game agencies, the Environmental Protection Agency and the Corps of Engineers to develop environmental baseline data, assess trends, identify the causes of decline and formulate recommendations for restoration and enhancement.

In closing, I want to say thank you for having me join you. If you see me during the next few days, please introduce yourselves. I want to hear what's on your minds. And I look forward to working with you. Who knows, together we just may move a few mountains and paint a few greener pastures.

Where is BLM Headed?

Cy Jamison
Director
U.S. Bureau of Land Management
Washington, D.C.

I appreciate this opportunity to meet with you today to share some exciting new efforts we're undertaking in our recreation, fish and wildlife and riparian programs.

Of our nation's public lands, 272 million acres are administered by the Bureau of Land Management (BLM) in the 10 western states and Alaska. Most of this vast area is prime habitat for over 3,000 species of fish and wildlife, many of which are economically and recreationally important.

With the population of our country shifting westward, our previously unoccupied public lands have suddenly become more popular among Americans for recreation and tourism activities. As greater demands for economic recreational use are being placed on our public lands, it has become increasingly important for the BLM to become more responsive to public needs.

For instance, BLM public lands receive over 60 million visits a year from recreation-minded individuals like you and me, who hunt, fish and pursue other related activities.

As we try to meet this increasing demand, I believe it is critical that BLM managers address fish and wildlife issues early in the land use planning process to get solid, workable answers to potential conflicts. I am committed to strengthening our work force of biologists and botanists to ensure this happens.

In an effort to elevate the importance of BLM's fisheries and wildlife program, I have appointed Mike Dombeck, a Ph.D. in fisheries biology, as my special assistant and advisor on fish and wildlife issues. I believe Mike will improve the understanding of our needs in the Department, Congress and within the conservation community.

Also, two vital new program initiatives have been developed and are being implemented. They are "Recreation 2000" and "Fish & Wildlife 2000."

Recreation 2000 provides a blueprint for the future of BLM recreation management. It provides a clear statement of policies and goals, addresses a number of challenges in program management and lists objectives for resolving each of them.

Equally important is the BLM's Fish & Wildlife 2000 plan. It describes goals and objectives for more efficient and intensive management of the variety of fish and wildlife resources on the public lands. BLM is implementing national plans to achieve these goals.

We're very excited about the many new steps we're taking at BLM to make this a true multiple use agency. Examples of on-the-ground initiatives already include interagency plans for management of waterfowl/wetlands, fisheries habitat, desert bighorn sheep, desert tortoise, and expanded cooperation and partnerships with interest groups and state and federal agencies.

One of our newest partnerships, and one I am particularly proud of, involves Ducks Unlimited. This agreement, signed last month, will allow us to work together through on-the-ground projects such as wetlands inventories, dike construction and vegetation planting. This would occur primarily in Alaska where we have 19.7 million acres of wetlands that furnish habitat for waterfowl and other wildlife.

Under the agreement, Ducks Unlimited will provide BLM with valuable advice, engineering expertise and financial assistance on joint projects. Together over the next decade we hope to inventory about 12 million acres of wetlands, improve 1.7 million acres and expand BLM's wetlands by 79,000 acres.

This partnership will strengthen our Fish & Wildlife 2000 strategy for managing the nation's valuable wildlife resources in the coming decade, and help achieve the goals of the North American Waterfowl Management Plan. This plan, developed by the United States and Canada in 1986, establishes waterfowl population goals that the two countries believe will meet the future public demand for recreational enjoyment of waterfowl.

To ensure that the American public will continue to enjoy fishing opportunities on the public lands, BLM is implementing a dynamic series of actions to benefit recreational and commercial fishermen.

For example, successful completion of our Anadramous Fish Habitat Management Strategy Plan will increase the numbers of adult salmon and steelhead trout produced on public lands. The estimated increase will be 20 percent, or 172,000 fish per year, with a return on investment of at least 2.5 times the cost.

Also, in an important cooperative step forward, the BLM and Forest Service will be signing a National Recreational Fisheries policy and action plan at 2 p.m. today.

This policy and action plan was developed in partnership with the International Association of Fish and Wildlife Agencies, the recreation and fishing industry, and the American Fisheries Society. The theme of this new program is "Fishing Partners with You."Come and join Dale Robertson and me for the official signing.

Naturally, implementing our recreation and fish and wildlife programs requires money. In 1985, Congress established a Challenge Cost Share Program for BLM. And we're taking advantage of it.

In Fiscal Year 1989, BLM received $1.5 million which were matched by outside funds from 36 organizations. Together we completed over 60 projects and had an additional 150 projects on the shelf, ready to go.

In Fiscal Year 90 we were appropriated $2 million for the cost sharing program which we estimate will be matched by well over $2 million in outside contributions. Through this and other approaches, we are involving many organizations in the implementation of our on-the-ground projects.

And speaking of money matters, BLM has asked Congress for an additional $2.9 million in FY'91 for its fish and wildlife program and for an increase of $4 million for its recreation program.

Another big change concerns our land acquisition program, where we've asked for an increase of $11.7 million in our FY '91 budget. This would allow for 16 land acquisitions for wetlands, recreational uses and special designations—including Desert Tortoise habitat in the Mojave Desert in California.

The proposed 1991 budget increases aren't going to finish the job, but they would be a great start. They also indicate that not only am I serious about recreation and fish and wildlife but so are Secretary Lujan and President Bush.

I've told you about BLM's plans for upgrading our recreation and fish and wildlife programs. Now let me mention a third area that is a priority of mine—riparian areas.

Our riparian program forms a vital link between different parts of our multiple use mission.

I will emphasize riparian area management through an initiative called ''Riparian Strategy for the 1990s.'' This plan is currently being shaped and should be completed this summer.

As a part of this strategy, and to help bridge the gap between livestock operators and wildlife interests, I want to develop localized BLM partnerships with wildlife groups and cattlemen's associations. I want to get down to the grassroots level. We need local workshops and more demonstration areas to show how effective riparian management can benefit both cattlemen and wildlife.

One final priority should be mentioned. We're going to have to work hard to improve access to public lands that are isolated by surrounding private property, which makes access and management difficult. This is a common problem in many Western states.

To help lessen this problem we must look at developing innovative cooperative efforts with landowners and continue to focus on land exchanges and acquisition opportunities. This is one area where I see the Land and Water Conservation Fund continuing to play a vital role. In fact, BLM has 72 projects currently proposed for future acquisition through the Fund.

One example where the fund has been very helpful is our acquisition from The Nature Conservancy of the Warner Valley Wetlands in southcentral Oregon. They call these lands of marsh and open water a ''duck factory'' because of their location and productivity along the Pacific Flyway. The acquisition will enable us to effectively manage this wetland complex.

The recreation, fish and wildlife and riparian programs along with land exchanges and acquisitions are key programs for the future of the nation's public lands. But this is just the beginning.

The Bureau of Land Management and the organizations you represent need to work together to keep the opportunities the public lands offer available for our children and future generations. I look forward to working with you toward this goal.

The U.S. Fish and Wildlife Service: Charting a Course for the 1990s and Beyond

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

What a great pleasure it is to be here and to see so many old friends. This morning, I have the honor to appear before you as new director of the U.S. Fish and Wildlife Service. This is certainly a new role for a kid from Wyoming. As a rancher, outfitter, conservationist and state senator, I spent two decades criticizing the federal government. Now I stand before you as part of the problem.

On behalf of the Fish and Wildlife Service, the President and people across America, I want to salute you, your staffs, and your members for your efforts on behalf of wild resources. As we meet here today, the pressures facing our wildlife resource are greater than at any time in our nation's history. Global warming, ozone depletion, deforestation, loss of biodiversity, toxic contaminants, over development and continued whittling away of critical habitat—these are some of the alarming phenomena of our times. You here in this room know the real meaning behind these words. You have held a dead duckling in the palm of your hand. You have seen a woodland empty of migrant warblers. You have quantified the parched wetlands, lost winter range and degradation of coastal estuaries. The battles and challenges are endless—and coming with more and more frequency.

Yet as great as these problems are, we here today have a wonderful opportunity—and a grave responsibility. This, the 20th anniversary of Earth Day, marks the beginning of a historic decade for wildlife conservation. Polls clearly show the American people are deeply concerned about the world's environment. That concern rates high with conservatives as well as liberals. In many ways, our nation's citizens are depending on those of us who work as professional conservationists to lead the way to a better future. If we fail to act now, the 21st century will dawn on an America that is vastly poorer in the fish and wildlife resources, and in the quality of the human environment, than it is today.

In 1854, Chief Seattle said: "What is man without the beasts! If all the beasts were gone, men would die from a great loneliness of the spirit. For whatever happens to the beasts happens to man." The reality of that prophecy shouts at us today. None of us wants to see the continuing depletion of our wild resources come to pass. Each of us has a special responsibility to give of ourselves to make sure it doesn't happen.

The responsibility of the Fish and Wildlife Service is a vast one. The diversity of its mandates, challenges and programs are remarkable—at times even overwhelming. I want to continue a tradition of achievement and build upon its fine legacy. I want to be sure the Service is ready to meet the conservation challenges of the 21st century.

I want to maintain and enhance the Fish and Wildlife Service's reputation for professionalism and credibility. That means we will make decisions based on sound biological information. There will be no substitute for good science in what we do. But it also means we will need to take a close look at how we do business and make changes where needed.

I've only been in this job a short time. But there are advantages to being a rookie bureaucrat. One is that you can bring a fresh outlook to the issues confronting a complex agency like the Service. We are in the midst of a thorough and complex, but very specific overhaul of our mission—remolding the objectives of our dozens of programs. I am determined that this effort will build a visionary and responsible road map to the agency's future.

I am concerned about the overall system by which the Fish and Wildlife Service charts its course. The rate of change in today's world is so great that we cannot merely react to situations as they arise. We must anticipate trends. We must focus on the future with a vision of what the agency should accomplish. We must be systematic in allocating our resources to accomplish that vision. We must share our vision with the American people. And, we must document our progress, I intend to make sure that the Fish and Wildlife Service has a management system that will allow it to do the right thing—and then to do the thing right.

At this time we have task forces critiquing and remolding many of our activities: Endangered species, refuge management, fisheries, training, coastal estuaries, law enforcement, nongame and contaminants, to name a few. We are asking: where are we? Where do we want to go? How are we going to get there? And, did we make it? We are evaluating, analyzing, and laying new track to the future so our efforts will be successful. We solicit your input and help.

After my remarks this morning, I will have the privilege of signing—with Tony Clarke—a new memorandum of understanding for conservation of the whooping crane. The 25 years of cooperation between our countries on behalf of the whooping crane—and the progress of that effort—serve as a model as we strive to develop our relationships with the world community. Secretary Lujan has a special interest in developing positive programs south of the border. As Assistant Secretary Harriman has mentioned, we have partnership efforts building in such diverse areas as Mexico, Africa, Latin America, and the Soviet Union.

On the fisheries side of our operations, I am very encouraged by the progress of some of our restoration efforts, such as the recent increases of Chesapeake Bay striped bass. In this year's budget, the President is requesting an increase in our fisheries budget of almost 30 percent over one year ago. In fisheries, we are trying, with success, to be a more positive player in aquaculture. I believe we must seize the opportunity to work with aquaculture to minimize the potential risk to wild fish stocks and public fish culture activities.

In support of recreational fisheries, I have recently approved a Service Recreational Fisheries Policy. I believe that this Policy is an important step in emphasizing the role of fisheries in the Service. It will place more emphasis on key areas—the Great Lakes, Atlantic Salmon and the Central Valley of California.

Wetlands. Certainly a long overdue but timely theme for these times. Much has been written and said lately about progress, or lack of it, on the no-net-loss of wetlands goal set by President Bush. Especially within the Washington Beltway, there seems to be a certain amount of gumming going on with friends in the press. Is this Administration committed to wetlands? Such questioning and skepticism are not unexpected or even inappropriate. However, let me say, from the perspective of the Fish and Wildlife Service, we are getting excellent support from President Bush and Secretary Lujan. In the President's budget, we are asking for an unprecedented total of $129 million dedicated to wetlands. You all are going to be pleasantly surprised as you see the programs going on now and that will surface from the Service and the Department of Interior.

The U.S. Fish and Wildlife Service has stronger support for its wetlands programs today than at any time in its history. We have a President who cares about the environment in a direct and more personal way than any President since Theodore Roosevelt. If you need any proof that the President is one of us, remember who helped push through the Wallop-Breaux program. And remember who came to the rescue when the number-crunchers wanted to put a cap on Wallop-Breaux and Pittman-Robertson outlays.

Within the Department of the Interior, the Service has the full backing of Secretary Lujan and Assistant Secretary Harriman, who have a strong interest in the North American Waterfowl Management Plan and our other wetland activities. I stand before you today as a Director whose budget is the largest ever proposed for the Fish and Wildlife Service by any Administration—a total of over $936 million. This comes at a time when all of us understand the need to cut Federal spending to reduce the deficit.

If the no-net-loss goal continues to fuel debate, I call that good. I call it democracy. Wetlands are on the national agenda of serious environmental issues, we are making progress, and I pledge to you we are going to make considerably more progress in the months ahead.

I believe in *partnerships*. Hopefully you are seeing positive signs from the Fish and Wildlife Service as we strive to strengthen partnerships with other federal agencies, states, conservation organizations, commodity groups and corporate America. I am sure you will agree that the longterm well-being of our nation's wildlife will depend directly upon the good will and support of our farmers and ranchers.

Over 60 years ago, Aldo Leopold told us about the importance of private lands in maintaining abundant wildlife. The Fish and Wildlife Service *must* provide leadership in this effort. This coming year, we plan to have the Service actively involved in the critical discussions involving reauthorization of the Farm Bill. Also, I am proud today to announce the unveiling of a new Service national private lands initiative we've dubbed STEWARDSHIP 2000.

This program encourages partnerships between landowners and wildlife professionals to improve habitat, not just on wetlands but on other important habitats as well. It makes Service people and equipment readily available to landowners who want to do something for wildlife. This effort will complement existing programs and will be an important part of Service wetlands activities and the North American Waterfowl Management Plan.

I need to take time out here for a minute to thank all of you for the support you have given to the North American Plan. We have made some terrific gains over the past year. The passage of the North American Wetlands Conservation Act is a major landmark. We are moving as quickly as possible to implement that new law, and, as most of you know, Secretary Lujan has already named the members of the North American Wetland Conservation Council to advise us on the expenditure of the new funds for the Plan. Most of them are here, and the council's first get-together was held here last night.

But we have plenty more to do. It's a little too early to be certain, but it looks like ducks could be in for another year of tough nesting conditions in the prairies. Lloyd Jones, Commissioner of the North Dakota Game and Fish Department, says the word ''drought'' is an understatement for the conditions there. Migratory birds are going to continue to need all the help they can get from us. In particular, I urge you to do whatever you can to get out the word about the Plan. Don't just speak to the hunting community. Try to reach the birdwatchers, anglers, hikers, educators and others who care about wildlife. The habitat work under the Plan will benefit a host of critters, and that's a message we need to keep sending to the public.

This brings me to one of my personal goals for the Service in the 1990s. I believe it is vitally important for the Service to broaden its constituency. I believe the hunters and fishermen, who are the backbone of our traditional constituency, will welcome new allies in the cause of preserving habitat.

One way we can expand public support for conservation is by increasing our nongame wildlife programs. In the long run we need to look much harder for ways to save groups of species that are beginning to decline. I believe the Fish and Wildlife Service can do more to preserve biodiversity, to save unique communities and ecosystems and to prevent more species from reaching the brink of extinction. This is an area we plan to continue to explore.

The Service's emphasis on these important areas will increase naturally as we enhance nonconsumptive values of wildlife, including biodiversity, in the course of improving our endangered species, refuge, contaminant monitoring and wetlands programs. But beyond this, we must remember that the future of our wildlife in the 21st century will rest with today's young people, especially minorities, many of whom are growing up with no opportunity to fish, hunt or watch birds. In some ways, today's youngsters are as beleagured as our wildlife resources. We can help them resist and overcome the temptations of illegal drugs by teaching them to see the beauty and wonders of our natural world. We must teach them. We must provide opportunities for them to get involved. We must reach out and build responsible ethics. We must find the best of them to become tomorrow's wildlife users—and even managers.

Wild places and wild critters are important segments of our nation's roots. They are vital indicators of the overall well-being of our society. Wild places and wild critters are essential elements in the American standard of living. Wildness is an inherent ingredient of the American dream.

It is our task to keep that spark of caring alive in the hearts of our young people, and to fan it into a flame of intense determination to preserve all the life of this amazing and wonderful world. We must take care that we do our jobs well, to nurture our living resources and to pass them along whole and healthy to our children. That's what all of us are doing here today. Let's get to work as a team like never before to make the 1900s a turning point in the history of wildlife conservation.

Special Session 1. *Wildlife, Fisheries and the Conservation Reserve Program*

Chair
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Lubbock

Cochair
RONNIE R. GEORGE
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Introductory Remarks

Ronnie R. George
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Austin

Fish, wildlife, and agricultural crops are products of the land and as such are extremely sensitive to intensive land use and soil erosion. Organized efforts to reduce soil erosion in the United States have been around since the Dust Bowl days of the 1930s. In 1935, the U.S. Soil Conservation Service (an agency of the U.S. Department of Agriculture) began helping farmers solve soil erosion problems. In the 1950s, school children prepared posters and wrote themes for "Soil Conservation Week." In the 1950s and early 1960s many farmers participated in the "Soil Bank Program," which temporarily retired approximately 20 million acres of cropland from production nationwide. However, by the 1970s, all-out "fencerow to fencerow" crop production was again the name of the game. During the 1970s, millions of tons of soil and thousands of tons of fertilizer, herbicides, and insecticides were blown or washed into streams, rivers and reservoirs to the detriment of fish and wildlife.

A new era in American soil conservation began in December 1985 with the signing of the 1985 Food Security Act. The Conservation Reserve Program (or CRP) is a major provision of this Act. Patterned somewhat after the old Soil Bank Program of the 1960s, CRP was designed to reduce soil erosion by taking highly-erodible land out of production and placing it under some type of protective cover for a 10-year period. This, of course, should have positive effects on fish and wildlife resources. A 1986 U.S. Department of Agriculture slide presentation called CRP the "Conservation Challenge of the Century." As you listen to the following speakers, see if you believe CRP has met that challenge.

Effects of the CRP on Wildlife Habitat: Emergency Haying in the Midwest and Pine Plantings in the Southeast

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Introduction

The Food Security Act of 1985 authorized a Conservation Reserve Program (CRP) that pays farmers who plant permanent cover on highly erodible cropland. The CRP could benefit wildlife greatly, but differences between the CRP and previous set-aside programs make it difficult to predict benefits or identify program changes that could produce even greater benefits. We initiated our study in 1987 as a cooperative effort among the states and the U.S. Fish and Wildlife Service. Our intent was to describe the establishment of vegetation and the trends in wildlife habitat on CRP fields and to make these results available for Congress. The study was designed to analyze differences between conservation practices for 1986 and 1987 contracts.

The purpose of this paper is to evaluate two aspects of the CRP that have created considerable controversy: (1) the impact of the 1988 emergency haying on CRP lands; and (2) the impacts of conversion of cropland to pine plantations on the winter food supply for northern bobwhites (*Colinus virginianus*) in the southeastern United States. These two issues are important for the following reasons.

On June 2, 1988, the U.S. Department of Agriculture (USDA) responded to a severe drought across much of the country by allowing landowners to harvest hay on CRP fields. Haying was restricted to established CRP fields planted in 1986 or 1987 and required that at least 25 percent of the field area be left for wildlife cover. Emergency haying is a concern because of possible nest destruction and mortality of ground-nesting birds, plus reduced nesting cover available for the next year.

During the last quarter century, young upland forests increasingly have replaced cropland in the Southeast (U.S. Department of Agriculture 1980). Over a similar period, southeastern populations of northern bobwhites have declined (Flather and Hoekstra 1989). Many biologist suspect that tree plantings in the Southeast reduce northern bobwhite winter food supplies. They fear that CRP tree plantings will further diminish food supplies, depressing quail populations still more.

Materials and Methods

Haying

To address the haying issue, data were collected in 1989 on 394 CRP fields from 22 sampling populations (Farmer et al. 1988) in CP1 (tame grass), CP2 (native grass), and CP10 (already grass). Each field was visited before greenup and during midsummer. Biologists recorded the percentage of the field that had been mowed and whether or not the cuttings had been baled.

Our study was originally designed to report habitat conditions for an entire field, thus we had to classify each field as either mowed or unmowed. If a biologist reported that 25 percent or more of a field had been mowed, and if at least two of the three sample points had also been mowed, then that field was classified as "mowed" ($n = 232$). We calculated mean visual obstruction readings (VORs) (Robel et al. 1970) for each field from the field data.

Mowing is a standard practice during establishment of permanent cover in many areas. Also, mowing for weed control has been required by county Agricultural Stabilization and Conservation Service (ASCS) offices and local weed control districts. We subdivided mowed fields into two classes depending on whether the clippings had been baled ("hayed") or not ("maintenance"). Our statistics on the percent of mowed fields and the percent of field area that was cut were calculated using simple averages across all samples in each class. They should be considered estimates.

At three randomly selected points in each field, the biologists collected data on VOR's, herb height, herb canopy cover, and proportion of the herb canopy that was grass (Hays et al. 1989). We calculated mean VOR's for each population and for mowed and unmowed fields from the individual field data. To calculate class means from the population values, we weighted by the proportion of all CRP contracts in that given population.

The VOR measures cover available on a field and reflects nesting suitability for ring-necked pheasants (*Phasianus colchicus*). Using a transformation curve developed by pheasant biologists (Hays et al. 1989), we calculated indices of pheasant nesting habitat suitability (ranging between 0 for no habitat to 1 for ideal habitat) for each field from the average VOR. We calculated weighted averages for this index across conservation practices and years.

The VOR also measures nesting habitat suitability for eastern and western meadowlarks (*Sturnella magna* and *S. neglecta*). We developed a single habitat suitability index model for eastern and western meadowlarks by revising an existing model (Schroeder and Sousa 1982). The variable "mean distance to a suitable perch" was dropped for the Midwest region because local biologists judged it was not limiting. Also, we estimated the variable "mean height of herbaceous canopy in midspring" by averaging pregreenup and midsummer VORs then converting VOR into height. To predict height from VOR, we regressed VOR against herb canopy height for individual measurements, getting herb height = 0.695 VOR ($p < 0.001$). We computed habitat suitability indices for each field from average values of habitat variables for that field. We then computed weighted means for conservation practices and years as described above.

Trees

To assess the CRP's effect on converting cropland to forest, we used data from USDA to calculate the ratio of cropland to forest in the six southeastern states encompassing the Piedmont region (AL, MS, GA, SC, NC, VA) (U.S. Department of Agriculture 1982). We calculated the changes due to the CRP by subtracting the total area of CRP contracts (through the seventh signup) from the area of cropland for these states and then added the area in tree plantings.

To assess the effects on the northern bobwhite's winter food plants, we compiled data collected in 1988 across the Southeast Study Region by cover type. Field biologists collected data from 228 40-acre circles centered at random points on the margins of CRP fields. They produced a cover-type map for each circle using a standardized list of 33 cover types, which yielded a total of 647 mapped cover-type areas. In each cover-type area in the circle, the biologists randomly located a line transect. Presence or absence of the northern bobwhite's preferred winter food plants (based on State-specific lists) was determined for at least 50 point intercepts at 20-foot intervals along the transects. We averaged mean canopy cover values for each cover-type area across all circles containing that cover type to get means for each cover type. We converted canopy cover percentages for each map unit into winter food suitability indices using a curve by Schroeder (1985).

To examine how changing the ratio of cropland to forest in the Piedmont affected the northern bobwhite's winter food supplies, we looked at the mean canopy cover of the preferred food plants in two cover types of pines (many planted on non-CRP lands). Although we do not have direct data on the availability of northern bobwhites' winter food on cropland, we did attempt to get general information about the types of crops and cultivation practices in the Piedmont region. We also calculated the canopy cover values for the food plants in the grass-dominated CRP conservation practices of tame grass (CP1), native grass (CP2) and already grass (CP10).

Results and Discussion

Haying

How much haying occurred? Data from the ASCS indicates a large variation in the percentage of the CRP that was affected by emergency haying (Figure 1), with

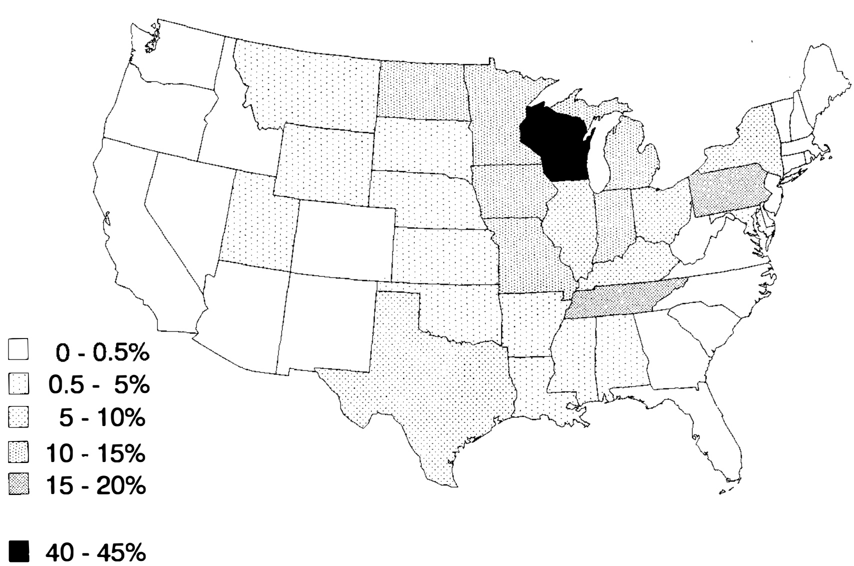

Figure 1. Percentage of CRP acreage hayed in 1988 (USDA data, base is signups 1–4).

the greatest percentage reported for Wisconsin (45 percent). Across the entire United States, 7.7 percent of all CRP acreage in the 1986 and 1987 contracts (through the February 1987 signup) was hayed.

When we analyzed our data, we found the following. Considering all samples together, 20 percent of the CRP fields were hayed. Of these, 88 percent of the field area was mowed. Also, 84 percent of the hayed fields had more than 75 percent of their area mowed; 33 percent were completely mowed. This appears to violate the rules for haying. However, the subjective estimates of area may have been inaccurate, some mowing for maintenance may have been done on the same fields that were partly mowed for hay, or errors may have been made in determining in late winter whether cuttings had been baled the previous summer. These considerations notwithstanding, it seems likely that haying on many fields exceeded legal limits.

Of the maintenance mowed (i.e., mowed but not baled) fields, 21 percent were more than 25 percent mowed. Of these fields, the mean subjective estimate of the area mowed was 87 percent. Also, 82 percent of these fields had more than 75 percent of their area mowed, and 55 percent had been mowed completely. One field had been completely mowed twice, in mid-June and again in mid-September.

Some fields may have been hayed that would otherwise have been mowed for maintenance. Because added mowing is required when fields are being established, the mowing rates should decline through time, approaching a constant level. This should be similar to the level we found on fields in the "already grass" (CP10) conservation practice in our 1988 pregreenup data set. We classified those CP10 fields as mowed or unmowed using the same criteria as for the 1989 data (greater or less than 25 percent of their areas mowed in the pregreenup observations in 1988). The weighted mean number of fields mowed (across 1986 and 1987 contracts) was 21.6 percent. This is similar to the 21.0 percent value discussed for fields mowed but not baled in the 1989 data set. Apparently, the haying was in addition to the mowing that would have occurred for maintenance.

When was the 1988 haying done? The timing of haying is important because of possible nest destruction and mortality of hens. The long-term average median hatching date for pheasant eggs is about June 10 in both Kansas (K. Church, pers. comm. 1990) and Minnesota (A. Berner, pers. comm. 1990). We have no direct field observations on when haying occurred, but ASCS data show that the first counties were approved for haying on June 3, 1988 (Figure 2). Fully 30.2 percent of the counties that were approved for emergency haying in 1988 had been approved by June 10. No one has reported significant delays between approval date and when farm operators began haying. Hence, about one-third of the hay was likely cut during the period when about half the nests were still being incubated.

Hartman and Scheffer (1971) reported an average of 35 percent of incubating hens were killed when a field was mowed. Furthermore, almost no production occurs from nests disturbed during mowing (R. Warner, pers. comm., 1990). Hatching does not guarantee survival. Chicks suffer significant mortality if mowing occurs within the first two weeks after hatching (R. Warner, pers. comm. 1990).

Using data on the long-term average date of hatching from Kansas (K. Church, pers. comm. 1990), we calculated a period for nest and brood vulnerability starting 37 days before hatching (Buss 1946) and extending two weeks after hatching. These results are superimposed over the graph of approval of counties for haying (Figure

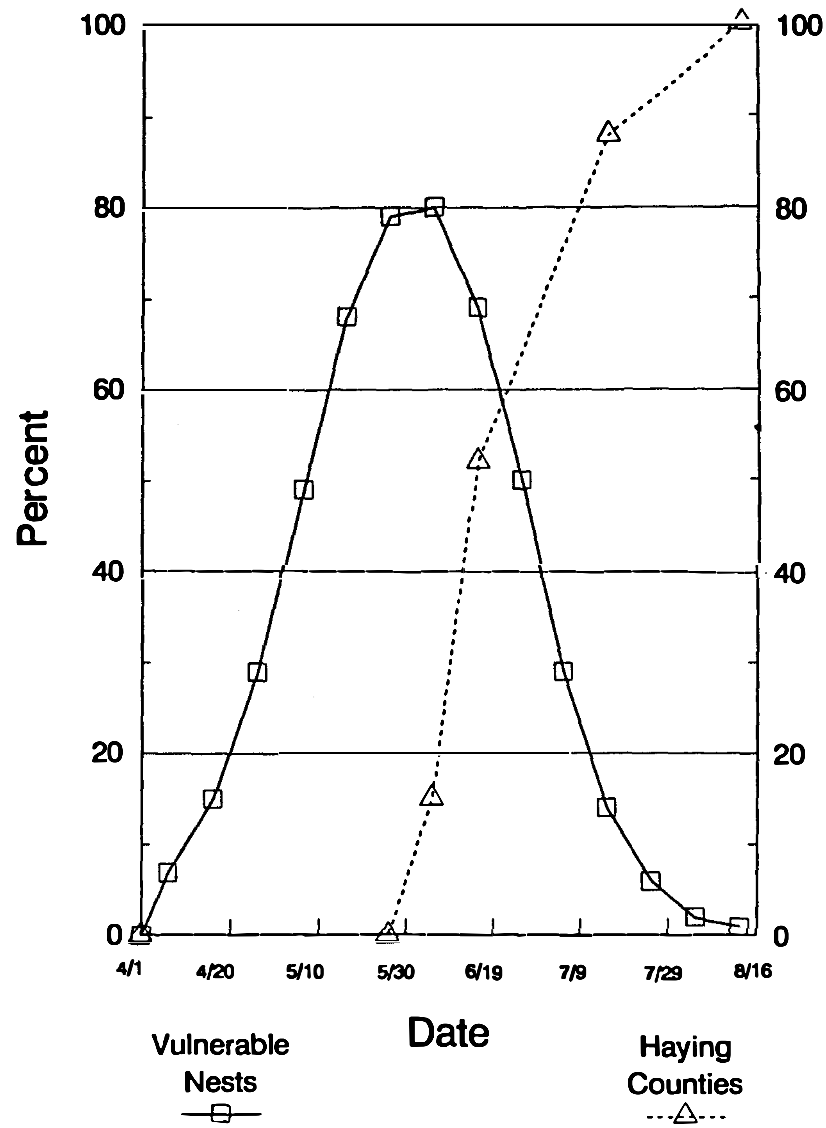

Figure 2. Timing of approval of haying versus vulnerability of nests and broods. ("Vulnerable nests" is the percentage of all nests and young broods vulnerable to mowing at a given date. "Haying counties" is the number approved by a given date expressed as a percentage of all counties approved in 1988.)

2), showing considerable overlap. In most parts of the Midwest, more pheasant production occurs later in the year than suggested by Church's Kansas data (R. Warner, pers. comm. 1990), so the overlap may be greater than shown.

While haying may potentially impact pheasants, we must first establish that pheasants actually nest in CRP fields. Pheasants are known to exhibit strong preferences for nest sites (Baskett 1947). Nest densities in good cover are often more than ten times as high as in marginal habitats such as small grains, even though the good cover types are less than one-tenth as abundant (Hill and Robertson 1988).

In the Texas southern high plains before the CRP, nesting was concentrated in playas and fields of small grain (Taylor 1980). Berthelsen (1989) measured nest densities on well-established CRP grass stands in that area. He found nest densities up to 2.41/ha, which exceeds the average for the primary pheasant range of North America. This shows that CRP can be very attractive to nesting hens. Very likely, grassy CRP fields provide the best pregreenup cover in many parts of the Midwest, attracting pheasants that would otherwise nest elsewhere. Mowing the CRP fields during the nesting or early brooding period could well result in actual declines in pheasant reproduction in the area. Conceivably, mowed CRP fields could be an effective ecological trap. If this phenomenon is significant, counties with relatively high CRP enrollment and high haying should show actual declines in pheasant populations (A. Berner, pers. comm. 1989), and relative scarcity of late-hatched chick age classes. Biologists with appropriate census data may wish to look for this effect.

What was the impact on pheasant habitat quality for 89? Table 1 shows the VOR and pheasant nesting habitat quality index values for mowed and unmowed fields in each conservation practice. Across all conservation practices pheasant nesting suitability was 0.81 and 0.87 for mowed and unmowed 1986 contracts respectively, and 0.76 and 0.86 for the 1987 contracts.

This shows that fields not mowed in 1988 had better average 1989 pregreenup cover than did fields mowed in 1988. The differences in nesting suitability are less dramatic than for the VOR readings. This occurs because many unmowed fields had more cover than necessary for optimum cover conditions.

What was the impact on meadowlark habitat quality in 1989? Table 1 also contains calculated meadowlark habitat suitability for mowed and unmowed fields. The results

Table 1. Comparison of visual obstruction reading (VOR), pheasant nesting habitat suitability index (SI), and meadowlark habitat suitability index (HSI) results for mowed and unmowed fields. Year totals are weighted means.

	Pregreenup VOR		Pheasant nesting SI		Meadowlark HSI	
Population	Unmowed	Mowed	Unmowed	Mowed	Unmowed	Mowed
1986 contracts						
CP1	2.8	1.6	0.84	0.49	0.48	0.52
CP2	4.5	1.9	0.95	0.93	0.44	0.50
CP10	2.8	1.5	0.89	0.81	0.56	0.70
Total	3.2	1.7	0.87	0.81	0.49	0.56
1987 contracts						
CP1	2.2	1.3	0.84	0.76	0.34	0.52
CP2	3.5	0.9	0.92	0.64	0.34	0.31
CP10	3.3	1.7	0.92	0.85	0.54	0.52
Total	2.5	1.3	0.86	0.76	0.38	0.50

show that mowing the preceding year slightly enhanced habitat quality. This gain occurred because fields mowed in 1988 had a greater proportion of grass in the herb canopy and a greater herbaceous canopy cover. Both of these changes are favorable for meadowlarks. According to the model, both grass and total herb canopy cover still limit meadowlarks on CRP fields. Habitat should improve as grasses become dominant, especially on tame grass plantings.

Pine Plantings

Has the CRP caused much change in the ratio of crops to trees? The CRP is having an effect on the ratio of cropland to forest (Figure 3). This is especially dramatic in North Carolina where the CRP has already decreased the ratio of cropland to forest by 38.8 percent. Other forces have caused cropland to be converted to pine plantations before the CRP. They have probably caused changes in land use not reflected in the 1982 baseline data that we used. Of course, these data do not assess changes in the ratios of cover types locally.

Has the conversion of cropland to CRP reduced northern bobwhite winter food supplies? Table 2 contains mean canopy cover values for preferred northern bobwhite food plants in various cover types and the corresponding mean suitability indices for northern bobwhite winter food. These values are high, especially in the cover types dominated by pines greater than 10 feet tall. This is because pine was considered a plant food. Recent reconsideration suggests that, while pine can be important, it infrequently contributes late-winter food.

General information about the crop plantings and cultivation practices from Soil Conservation Service state agronomists suggests that currently, many crops are either species (such as tobacco, cotton and small grains) providing little winter food for northern bobwhites, or winter food is made less available because crop stubble is plowed under before winter. Using very rough calculations, the suitability index for northern bobwhite winter food of cropland in the Southeast is about 0.2.

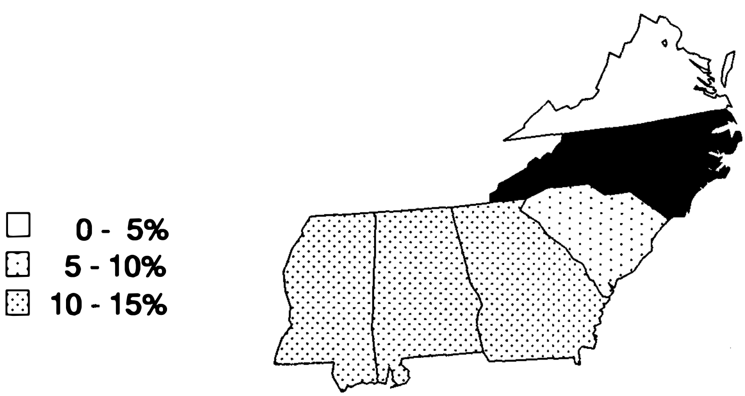

Figure 3. Decrease in the ratio of crops to trees due to CRP (USDA data).

Table 2. Characteristics of cover types in the Southeast, 1988.

Cover type	Number of fields	Northern bobwhite winter food plant canopy cover (%)	Bare ground (%)	Northern bobwhite winter food suitability index
Pine 0–10 ft	43	19.2	19.2	0.60
Pine >10 ft	10	40.1	10.1	0.86
Tame grass CP1	66	22.6	31.9	0.22
Native grass CP2	40	21.4	59.5	0.39
Already grass CP10	60	30.0	30.6	0.35

These results imply that the CRP is not reducing winter food supplies for northern bobwhites; and in fact, tree plantings may provide more food resources than other conservation practices. Reports from field biologists (e.g., M. Hall, South Carolina and D. Stauffer, Virginia, pers. comm. 1990) suggest that northern bobwhites are not using established pine plantings significantly. The apparent disagreement between our analysis and actual population response could have several causes. First, we did not consider the diversity or reliability of plant food species. Second, our analysis does not address the ratios of cover types within home-range areas. Third, it does not consider the juxtaposition and interspersion aspects of cover types that may limit the use of winter food. Fourth, we do not know that the food plants on CRP fields are actually producing seeds. In many plant species, only well-established and very robust individuals produce large amounts of seed. The dense and homogeneous old field conditions in CRP fields may result in so much competition between plants that seed production could be lower than implied by the cover values. Similarly, many preferred food species growing under a pine canopy may produce little seed.

To address the CRP's impact on northern bobwhites properly will require both analysis at the scale of individual home ranges—a capability we are developing—and the results of testing the northern bobwhite habitat model now underway by Dean Stauffer and his colleagues. It may also be necessary to assess actual production of late-winter food under CRP conditions.

Conclusions

Data from ASCS indicates that emergency haying CRP fields in the Midwest in 1988 significantly impacted ring-necked pheasant production. Most hay cutting started during the first nesting period of the year—the most productive one. Haycutting likely continued through the renesting period as well. Haying apparently exceeded the legal limit of 75 percent on many fields. Monitoring compliance of the actual amount of haying by USDA is clearly warranted, just as it is for other acreage-based USDA programs such as the various commodity support programs.

Maintenance mowing is extensive on CRP fields. This can harm wildlife by direct mortality and nest destruction, but mowing can somewhat improve habitat the next year for at least some species. For example, meadowlark habitat was better in 1989 on fields mowed in 1988 than on those left undisturbed. Whether this gain exceeds losses due to direct impacts of mowing in 1988 seems doubtful. However, if the grass-dominated CRP plantings are not renewed by some type of disturbance every few years, habitat quality will eventually decline. While wildlife might be better served by late-summer burning than mowing, it cannot be denied that occasional mowing may be better than no disturbance at all. Of course the best mowing would occur no more often than every three to five years, be done in late summer and be followed by raking to reduce and loosen litter. The current practice of mowing much of the CRP every year is detrimental to important wildlife resources, wasteful of energy, and harmful to the soil.

The CRP is helping to change the landscape in the Southeast, encouraging conversions of crops into pine plantations. Although we have no evidence yet that this is reducing the supply of winter food for northern bobwhites, the analysis to date has only considered conditions within cover types; and it seems to contradict reports from field biologists.

The CRP is not living up to its potential for providing quality wildlife habitat, but we must not overlook the benefits of the CRP in comparison with the previous use as rapidly eroding cropland. Not only is the habitat quality on CRP fields better than on most cropland, but reduced soil erosion and reduced use of chemical pesticides should ultimately benefit wetland wildlife and fisheries.

Acknowledgments

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Instream Benefits of CRP Filter Strips

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Introduction

The U.S. Environmental Protection Agency (EPA) and the U.S. Department of Agriculture (USDA) are both involved in developing programs that reduce the environmental degradation associated with agricultural activities. At EPA, the water quality impacts that are caused by runoff from farm fields to lakes, streams, and estuaries are an important issue for the Nonpoint Source water pollution control program. Similarly, USDA, pursuant to the Conservation Title of the Food Security Act of 1985, sponsors activities designed to provide protection of soil and water quality. Both agencies are often asked to show the environmental improvements that are being gained or that can be gained as a result of these programs.

In the case of agricultural programs, a lot of time has been spent developing best management practices (BMPs) to prevent erosion and runoff, but not much time has been spent measuring the ecological improvements that have resulted from the installation of these BMPs. Similarly, EPA does not presently conduct ecological evaluations in either the nonpoint or the point source programs on a regular basis. The focus is primarily on limiting discharges, rather than improving the integrity of the receiving water bodies.

In February, 1988, the eligibility requirements for the Conservation Reserve Program (CRP) were changed so that 100-foot field borders parallel to streams, lakes and estuaries could be leased to the federal government if left fallow. These field borders, or filter strips, do not have to meet the "highly erodible" criteria that upland CRP lands have to meet. This is because filter strips are expected to reduce the amounts of sediments, nutrients, and pesticides that flow into surface water and improve the habitat for fish and biota.

Since the program began, almost 50,000 acres of filter strip have been enrolled in the CRP. Intuitively we know that biological improvements will result from installing these filter strips, but the improvements are very difficult to quantify. Not surprisingly, most of the work that has been done to date focusses on the reductions in discharges to surface water that can be attributed to filter strips rather than on actual improvements in surface water ecosystems. Studies that focus on ecosystem changes tend to involve extensive monitoring over long periods of time and are confounded by changing land use patterns within a watershed.

In order to develop some estimates of actual improvements in stream quality prior to the reconsideration of the Conservation Title of the 1990 Farm Bill, staff at EPA conducted field studies that focussed on quantifying the ecological health of stream segments with filter strips and of similar stream segments without filter strips.

Methods

A major step in the study was the identification of watersheds that could be used to isolate and help identify the impacts of filter strips by minimizing confounding factors, such as animal waste discharges and urban runoff. An equal number of treatment and control sites with similar physical and land use attributes were sought for evaluation to facilitate the statistical treatment of the data. Rigorous criteria were applied to the identification and selection of filter strip and control sites.

A subset of sites in Maryland, Virginia, North Carolina, Ohio, Indiana and Illinois was identified for field reconnaissance. The results of field visits were used to select a final group of paired treatment and control sites in Indiana and North Carolina. Detailed water quality and physiographic measurements were conducted at the selected study sites. These results were later used in pairing streams to assure that confounding factors were minimized.

Biological Measurements

A number of indices were used to examine biological differences observed at the study sites. These indices served as indicators of environmental quality, integrating the cumulative effects of sediments and other pollutants. A modified index of biotic integrity (Karr et al. 1986), or IBI, based on fish communities was developed for use in this study.

Sampling was conducted in May and early June, 1989. In-situ macroinvertebrate samplers (Hester and Dendy 1962) were installed at each stream site, left in place for six weeks, and all colonizing organisms were identified to the lowest practical taxa. Fish in each study stream were sampled by electrofishing and identified to the species level.

Sample sites were located at the furthest downstream point of each stream that afforded a large drainage area and a minimum of potential non-cropland pollutant sources. In addition, sampling at treatment sites was conducted to include as large a filter-stripped length of stream as possible.

Statistical Comparisons

Statistical comparisons of the biotic indices were made both within treatment-control pairs and across pairs. Tests within pairs were conducted using the Wilcoxon Rank Sum test (Hollander and Wolfe 1973). For benthic invertebrates, the number of organisms and number of families in each of the Hester-Dendy samplers at each treatment site were individually compared with the numbers of organisms and families in each of the samplers from the corresponding control site. A similar approach was used for the fish data, where data from each of the stream segments at each site were used as the basis of comparison. Overall comparisons of treatment versus control sites were made using Friedman's Test (Hollander and Wolfe 1973), the nonparametric equivalent of a two-way analysis of variance with blocking by control-treatment pair.

Site Descriptions

Eight streams were identified for the study—four in North Carolina and four in Indiana. Within each state, there were two filter-stripped (treatment) streams and two corresponding unprotected (control) streams. Treatment-control site pairs were assigned within each state based on overall similarity of features including geographic proximity, drainage basin size, width to depth ratio, water depth, and stream valley confinement. Within each state, all sites were located within the same county and physiographic province. The original objective was to identify six pairs of sites in the two regions, but it was impossible to locate additional sites that did not have significant non-cropland sources of pollution (e.g., feed lots, septic discharges, urban runoff) in the watershed. At all sites, corn and wheat were the predominant row and non-row crops, respectively.

An analysis of stream morphological features indicated that the study streams fell within the Rosgen F-5 stream classification (Rosgen 1986). Streams in this class are typified by flat gradients, confined channels, meander paths, and silt/clay bottoms. The level of confinement found in such streams generally leads to enhanced sediment transport capacity and a high degree of erosion potential during runoff events.

Water Quality Conditions

Water quality analyses yielded results well within expected ranges for agricultural streams and do not provide evidence of pollution or contamination that might result in differences in stream biological communities unrelated to the presence or absence of filter strips. Observed values were typical of small streams draining agricultural croplands; the nutrient concentrations are neither indicative of pristine conditions nor suggestive of unusually high pollutant loadings. Dissolved oxygen (DO) was near saturation at all but one site. Temperatures were generally higher at the North Carolina sites, reflecting the more southern location. Conductivity was lower at the North Carolina sites than at the Indiana sites due to geological differences. The two Indiana control sites had the highest conductivities observed. The pH values were generally consistent within each of the two regions, with North Carolina streams being the more acidic. BOD_5 values at all sites were characteristic of relatively unpolluted surface waters.

There were no pesticides or herbicides detected in water samples collected at any of the Allen County, Indiana sites. Trace concentrations (i.e., less than 5 μg/l) of an unspecified breakdown product of DDT were observed at sites in Duplin County, North Carolina. No other pesticide or herbicide residues were detected in any of the samples.

Results

Macroinvertebrates

A total of 63 separate taxa were identified from the artificial substrates that were subjected to colonization for 6 weeks in the study streams. Typical of small headwater streams, the benthic macroinvertebrate populations tended to be dominated numerically by one or two taxa. Chironomids, haplotoxid oligochaetes, and (in Indiana streams) the air breathing snail, *Physa* sp., were the most common organisms encountered.

Numerical abundance. The total number of organisms per site ranged from 509 to 4,712 organisms. The total number of organisms at each treatment site was substantially greater than at its respective paired control site. These differences were statistically significant for three of the four control-treatment pairs. The across-pair comparison showed that macroinvertebrate numerical abundance was significantly greater ($p < 0.001$) at treatment sites than at control sites.

In all North Carolina streams, the benthic populations were numerically dominated by chironomids and oligochaetes and amphipods. In Indiana, chironomids were abundant at all sites. Without exception, the numerically dominant organisms were typical of low-gradient, soft-bottom, headwater streams of the physiographic provinces sampled.

Taxa richness. Family taxa richness for each site was based on all samplers combined. Family taxa richness ranged from 8 to 21; the differences were statistically significant ($p < 0.05$) for only two of the four pairs. However, the across-pair comparison showed that taxa richness was significantly greater ($p = 0.013$) at treatment sites than at control sites.

Fish

A total of 23 distinct species was collected during the study. Fourteen species were collected from the Indiana sites, and 11 species were collected from the North Carolina sites. Only two species of fish (yellow bullhead and bluegill) were present at both Indiana and North Carolina sites. Both subspecies of *Esox americanus* (i.e., redfin pickerel and grass pickerel) were collected in North Carolina. One hybrid sunfish (green sunfish × bluegill) was collected in Indiana. A total of 21 species were collected from the four filter stripped sites, while only 10 species were collected from the control sites.

Community-level Biotic Indices

Four indices were employed to examine differences in the quality of the fish communities between filter-stripped versus non-filter-stripped sites: species richness, species diversity, fish density and the index of biotic integrity (Karr et al. 1986). The four control-treatment pairs were considered individually and collectively in the analyses.

Fish species richness. Species richness ranged from 1–10 species per site and was greater at treatment sites than at the corresponding control sites for three of the four control-treatment pairs. In the fourth pairing, control site species richness and treatment site species richness were equal. The average number of fish species at the four treatment sites was 6.5, as opposed to an average of 3.5 species at each of the four control sites. The average ratio between control-treatment pairs was 2.04, i.e., average species richness was about twice as great at the filter stripped sites as compared to control sites. The across-pair comparison of species richness showed that richness was significantly higher ($p = 0.005$) at the treatment sites than at the control sites.

Fish species diversity. Values for the Shannon Index at the study sites ranged from 0.000 to 0.7824. Species diversity at treatment sites was greater than species diversity at control sites at all four of the control-treatment pairs. These differences were statistically significant (p = 0.05) for two of the pairs. Diversity averaged 0.49 at treatment sites and 0.23 at control sites. The average ratio between treatment and control site diversity was 2.25. Therefore, species diversity was roughly twice as great at treatment sites than at the corresponding control sites. The across-pair comparison showed that fish species diversity was significantly greater (p = 0.005) at the treatment sites than at the control sites.

Fish density. Density here is defined as the total estimated number of fish of all species at a site and is expressed in terms of numbers per 10 meters of stream. Total fish density at the study sites was highly variable and ranged from 0.07 to 46.1 fish per 10 meters of stream. On average, fish density was 1.6 times as great at treatment sites than at control sites, or 18.6 fish per 10 meters at treatment sites and 11.4 fish per 10 meters at control sites. The across-pair comparison showed no significant difference in total fish density between treatment and control sites.

Index of biotic integrity. Scores for a modified IBI at the study sites ranged from 11 to 27. The index was higher at the filter-stripped sites at three of the four control-treatment pairs. At the fourth pair of sites, the IBI's were equal (and very depressed), primarily the result of the small number of species collected at these two sites. Overall, IBI values averaged 20.5 for treatment sites and 13.5 for control sites.

Fish Population-level Indices

Comparisons of population size were made within control-treatment pairs, based on three replicates per site. The comparisons were limited to dominant species, defined as those species present in all three replicates at a given site. A total of 13 comparisons were made, 12 of which showed statistically significant (p = 0.01) differences in abundance of particular fish species within control-treatment pairs. In 9 of the 12 instances, the abundance of the individual species was greater at treatment sites. The species found to be more abundant at treatment sites within control-treatment pairs were American eel, redfin shiner, fathead minnow, creek chubsucker, black bullhead, bluespotted sunfish, green sunfish (two sites) and bluegill.

In three control-treatment pairs, higher population sizes were found at control sites. Species that were more abundant at these control sites were eastern mudminnow, common carp, and mosquitofish. These species are generally considered to be tolerant of degraded environments.

Summary

The results of the present study indicate that vegetative filter strips can provide benefits to the structure and function of aquatic ecosystems in first and second order streams draining agricultural croplands. Analyses of both benthic macroinvertebrate and fish communities showed significant differences between filter-stripped and control sites.

The use of biological communities as a basis for analysis takes advantage of the biointegration of chronic and transient effects by organisms within the communities. Thus, community quality will be a reflection of long-term effects, such as substrate alteration and nutrient loading, as well as short-duration events, such as pesticide applications or peak storm flows.

Most of the biological differences observed were statistically significant and suggest that vegetative filter strips can benefit aquatic ecosystems in small headwater streams in agricultural regions. Filter strips appear to protect the stream from the adverse effects of agricultural practices, including increased sediment and nutrient loading, altered hydrological regime, and habitat degradation.

Policy Implications

We hope that this information will be useful in thinking about the future of the CRP filter strip program. In the near term, the results will be incorporated into EPA's 1990 Report to Congress on Nonpoint Sources along with other information addressing the various benefits associated with filter strips.

In the long term, we will be encouraging the research community to pursue other applications of the methodology used here that lead to better measures of the effectiveness of numerous land management practices in areas threatened by agricultural or non-agricultural nonpoint sources. We also need some thinking about how this type of analysis can be done more cost effectively so that, where appropriate, it can replace traditional monitoring.

Last, but not least, there is a growing need for EPA, USDA and other organizations involved in the business of environmental protection to develop ways to measure environmental progress on a continuing basis. More widespread analysis of changes in the characteristics of biological communities may help in efforts to develop meaningful indicators of our progress (or failure to progress) in improving water quality.

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Ring-necked Pheasant Nesting Ecology and Production on CRP Lands in the Texas Southern High Plains

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Introduction

Title XII of the 1985 Federal Food Security Act implemented the Conservation Reserve Program (CRP), providing payments to farmers for planting permanent cover on highly-erodible cropland for a 10-year period. The primary objectives of the CRP are to control soil erosion, reduce surplus crop production, improve water quality, and provide wildlife habitat (U.S. Congress, House of Representatives 1986).

The CRP's greatest potential as wildlife habitat in the Southern High Plains (SHP) is to produce secure, high-quality nesting and winter cover for upland game birds (Berthelsen et al. 1989). Several past Federal land retirement programs including the Conservation Reserve of the 1956 Soil Bank Act, Agricultural Conservation Program of 1964–65, and the Cropland Adjustment Program of the Food and Agriculture Act of 1965 (Gates et al. 1970) have demonstrated that ring-necked pheasant (*Phasianus colchicus*) populations respond favorably to placing agricultural lands into permanent vegetative cover (Berner 1988).

With decreasing pheasant numbers in the U.S. (Dahlgren 1988) and an increasing public interest in upland game birds (Wooley et al. 1988), it is important to take advantage of the unique opportunity provided by the CRP to examine its potential impacts on pheasant production. The objectives of this study were to: (1) document ring-necked pheasant nest success on CRP lands and a control crop in the Texas SHP, (2) estimate pheasant production and recruitment rates on selected CRP grass mixtures in the central portion of the Texas SHP, and (3) provide management guidelines for CRP.

Study Area

Study areas were selected from the central portion of the Texas SHP within Castro, Deaf Smith, Hale and Parmer counties (Figure 1). The High Plains range in elevation from 2,700 to 4,000 feet (820–1,220 m) above sea level (Orton 1978) and have

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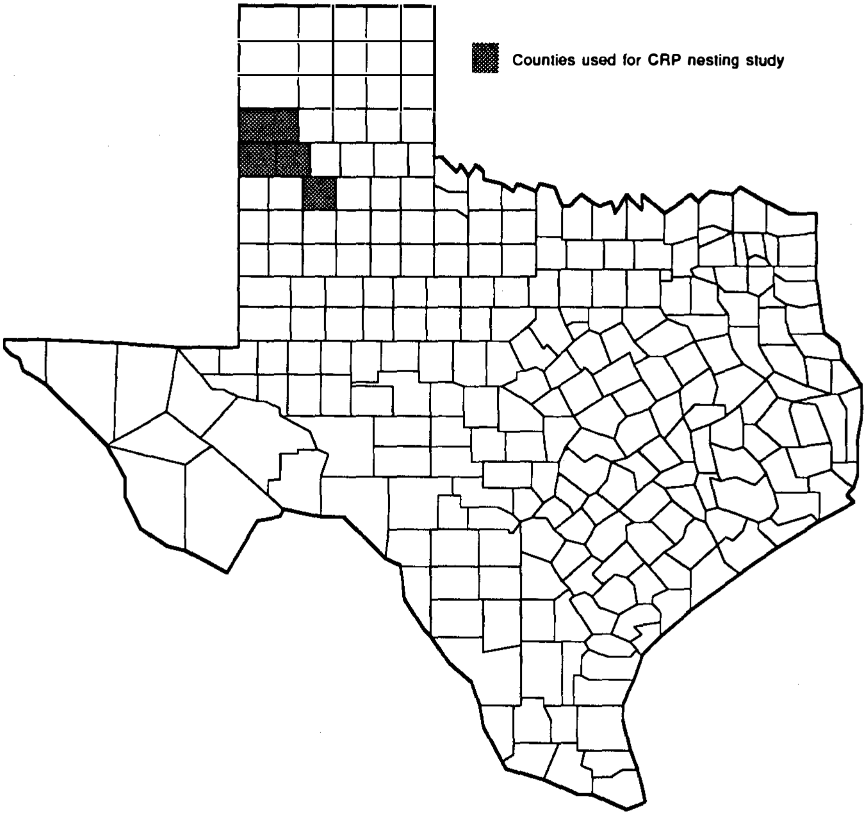

Figure 1. Area of the Texas Southern High Plains studied for pheasant nesting, 1988 and 1989.

about 25,000 playa lake basins (Bolen et al. 1989). The region has an annual relative humidity of 40 percent, and a mean temperature ranging from 55° to 64° F (13°–18° C) (Orton 1978). The annual precipitation is 20 inches (52 cm) (National Oceanic and Atmospheric Administration 1984). Snowfall averages 15 inches (38 cm) annually, with a mean freeze-free period of 211 days (National Oceanic and Atmospheric Administration 1984).

Prior to CRP, pheasant nesting habitat was provided in playa lake basins and fields of small grain crops (Taylor 1980). Pheasants are limited in the area by habitat deficiencies in nesting cover, winter cover, and travel lanes (Whiteside and Guthery 1983). Sparse pheasant habitat is the result of intensive row-crop agriculture, control of roadside vegetation, and irrigation practices (Taylor 1980, Whiteside 1983).

Agriculture is the primary land use in the four-county area. Agricultural crops consist primarily of corn, cotton, sorghum, and wheat. The area has 90 percent of its total land base in farms and ranches, with 46 percent of the total land base in planted cropland (Texas Agricultural Statistics Service 1986).

Methods

Field Selection

Established CRP fields chosen as study areas were selected based on their dominant established cover types, stand quality, establishment date, and field size. Blue grama (*Bouteoloua gracilis*)/side-oats grama (*B. curtipendula*) mixtures (BG/SO), blue grama/Kleingrass (*Panicum coloratum*) mixtures (BG/K), and blue grama/plains bluestem (*Bothriochola ischaemum*) mixtures (BG/PB) were studied because they were the most commonly established CRP cover types (Berthelsen et al. 1989). Corn was selected as the control crop because it was the dominant crop removed from production under the CRP. All fields selected were greater than 50 acres (20 h) and were established in 1987.

Four CRP fields of each cover type and four control fields were searched. Each field contained a 10-acre (4 h) plot that was searched for nests twice during the peak nesting season (May to July) at five-week intervals in 1988 and 1989. The same study plots were used each year, except four fields (2 BG/SO and 2 BG/K fields) that were mowed in 1989 by landowners. Replacement fields were selected from areas close to the original field.

Nest Data

The search-line method was used to locate pheasant nests (Gates and Hale 1975). Each pheasant nest bowl or depression containing two or more eggs was considered a nesting attempt to avoid confusion with promiscuously laid single eggs (Gates 1971). Information recorded at each nest included incubation stage, clutch size, vegetation structure and nest status. Nest fates were determined by periodically returning to the nest site to document its status. A successful nest was one in which one or more eggs hatched (Johnson 1979).

Most recent nesting studies of upland game birds and waterfowl have located nests by flushing hens, thereby not locating unattended or destroyed nests. The search-line method enabled location of more than 90 percent of nests (Gates and Hale 1975) and avoided this bias. The efficiency of the search-line method enabled searchers to locate pheasant nests without the presence of the female, in all stages of development, and with fates already determined.

CRP Vegetation

Vegetative structure of the CRP cover types was estimated using the visual obstruction pole technique (Robel et al. 1970). Twenty sample points were located per field. Sample points were laid out along step-point transects with pole readings taken every 10 paces for the first 200 paces of the transect.

Production and Recruitment Estimates

Pheasant production and recruitment estimates were determined using nesting information from 1988 and 1989 and survival estimates. Production was estimated only for the four-county study area (Figure 1). Estimates were restricted to the acreages containing the grass mixtures studied. CRP lands with the studied grass mixtures comprise only 4 percent of the total land area in the study area counties. Production was estimated assuming: (1) a 50:50 sex ratio of the chicks produced; (2) 50 percent chick survival to the fall (Gates and Hale 1975); and (3) 58 percent hen survival from fall to spring (Peterson et al. 1988). In order to provide production estimates that were similar in English and metric measurements, nest density estimates were presented to the second decimal place.

Statistical Analysis

Nest success data were summarized in a 2 × 2 × 3 contingency table (year × nest success × cover type) and analyzed for differences with a log linear model (Bishop et al. 1975). Two-way analysis of variance was used to detect differences in: (1) nest density between years and among CRP cover types; and (2) vegetative structure between years and among CRP cover types (Steel and Torrie 1960). Independent variables were year and cover type. When nest density or vegetative structure differences ($P < 0.05$) were detected, least significant difference mean separation procedures were used. The Chi-square test was used to detect differences in nest abandonment rates by CRP cover type.

Results

Nest Success

One hundred and eighty-five pheasant nests were located in CRP fields in 1988 and 1989 (Table 1). Fifty percent of the pheasant nests located during 1988 and 1989 were initiated before 15 May, and 95 percent by 16 June. Nest success did not vary ($P = 0.154$) by cover type. No differences ($P = 0.781$) in nest success by CRP cover type were detected between years.

Table 1. Ring-necked pheasant nest success and causes of nest mortality by Conservation Reserve Program cover type in the Texas Southern High Plains, 1988 and 1989.

			Unsuccessful by cause (%)		
Cover type[a]	Number of nests	Nest success (%)	Preyed upon	Abandoned	Other
BG/SO					
1988	12	8	76	8	8
1989	41	17	74	7	2
Years combined	53	15	74	7	4
BG/K					
1988	43	28	47	25	0
1989	47	28	59	13	0
Years combined	90	28	53	19	0
BG/PB					
1988	21	24	38	38	0
1989	21	10	86	4	0
Years combined	42	17	62	21	0
CRP average					
1988	76	24	49	26	1
1989	109	20	70	9	1
Years combined	185	22	61	16	1

[a]BG/SO Blue grama/side-oats grama mixtures.
BG/K Blue grama/Kleingrass mixtures.
BG/PB Blue grama/plains bluestem mixtures.

Nest abandonment occurred in 16 percent of the nests (Table 1). Nest abandonment in BG/SO mixtures (8 percent) was less than total abandonment ($X^2 = 6.125$, 2 df, $P < 0.05$) (Table 1). Clutch sizes averaged 11.2 eggs (Table 2) and differed ($t = 3.225$, 42 df, $P < 0.005$) between years (11.9 ± 4.03 versus 10.2 ± 1.86).

Nest Density

Pheasant nest densities were calculated using only nests located within study plots. No pheasant nests were located within control fields. Nest density did not vary by cover type in 1988 ($P = 0.217$), or 1989 ($P = 0.604$) (Table 3). No differences of nest densities within CRP cover types were detected between years for BG/SO ($P = 0.121$), BG/K ($P = 0.546$), or BG/PB ($P = 1.00$). BG/K mixtures generated high nest production (Tables 1, 2 and 3) throughout the study.

CRP Vegetation

Vegetative structure of CRP cover types differed between years (Table 4). Fields of BG/K mixtures had decreases in vegetative structure between years. The average CRP vegetative structure decreased from 1988 to 1989. Vegetative structure varied ($P = 0.051$) by cover type in 1988.

Production and Recruitment Estimates

A total of 116,188 acres (47,021 h) of CRP land containing the studied grass mixtures was enrolled in study area counties (Berthelsen 1989). Nesting information (Tables 1, 2, and 3) was used with acreage enrollment information to predict a production of 172,122 chicks from 15,895 successful nests in 1988 and 150,984 chicks from 16,266 successful nests in 1989, or an average production of 164,128 chicks per year from 16,104 successful nests. Production estimates were determined as the product of acreage, nest success, nest density, clutch size and egg fertility. CRP lands produced 41,032 juvenile males in the fall population, and 23,799 females in the following spring population. Recruitment estimates indicate a pheasant density of 0.35 males/acre (0.87 males/h) in fall and 0.20 females/acre (0.51 females/h) in spring. Under these conditions, spring hen density on CRP lands with the studied grass mixtures would be 131 hens/square mile (51 hens/km^2) from the previous years nesting effort.

Table 2. Ring-necked pheasant production ($\bar{x}$ ± SE) by Conservation Reserve Program cover type in the Texas Southern High Plains, 1988 and 1989.

Cover type[a]	Nests/acre	Nest success	Clutch size	Egg fertility	Chicks/acre[b]
BG/SO	0.58 ± 0.58	15%	10.6 ± 1.98	87%	0.80
BG/K	0.85 ± 0.53	28%	11.4 ± 4.18	92%	2.50
BG/PB	0.48 ± 0.59	17%	11.7 ± 2.78	94%	0.90
CRP average	0.63 ± 0.57	22%	11.2 ± 3.40	91%	1.41

[a]BG/SO Blue grama/side-oats grama mixtures.
BG/K Blue grama/Kleingrass mixtures.
BG/PB Blue grama/plains bluestem mixtures.
[b]Chicks/acre = nest/acres × nest success × clutch size × egg fertility.

Table 3. Ring-necked pheasant nest density/acre ($\bar{x} \pm$ SE) on Conservation Reserve Program lands in the Texas Southern High Plains.

Cover type[a]	1988	1989	Years combined
BG/SO	0.25 ± 0.13	0.90 ± 0.71	0.58 ± 0.58
BG/K	0.98 ± 0.70	0.73 ± 0.34	0.85 ± 0.53
BG/PB	0.48 ± 0.63	0.48 ± 0.64	0.48 ± 0.59
CRP average	0.57 ± 0.59	0.70 ± 0.56	0.63 ± 0.57

[a]BG/SO Blue grama/side-oats grama mixtures.
BG/K Blue grama/Kleingrass mixtures.
BG/PB Blue grama/plains bluestem mixtures.

Discussion

Nest Initiation

Pheasant nesting chronology in CRP lands was ahead of that reported for the same general area by Taylor (1980) in 1979 and 1980 (Table 5). Pheasant nest initiation peaks are subject to wide ranges of yearly variation (Gates 1971); however, nest initiation peaks in this study were consistent between years (22–28 April). Earlier nesting chronology in this study versus earlier studies (Table 5) may be related to: (1) increase of available nesting habitat (Trautman 1982) due to CRP; (2) more favorable weather conditions (Penrod et al. 1986, Peterson et al. 1988); or (3) hens entering the breeding season in better physiological condition (Gates and Woehler 1968).

Nest Success

The similarity in nest success among CRP cover types (Table 1) may be attributed to the variability of observed values. This factor may mask existing differences in nest success by CRP cover type. Pheasant nest success in this study was comparable to estimates of nest success in Castro County during 1979 and 1980 (Table 5). Taylor (1980) calculated nest success for pheasants nesting in playa lake basins, roadsides

Table 4. Vegetative structure (Robel et al. 1970) ($\bar{x} \pm$ SE) of Conservation Reserve Program fields selected for nesting studies in the Texas Southern High Plains.

Cover type[a,b]	Visual obstruction reading (inches) 1988[c]	1989
BG/SO	15.4 ± 6.30 A	10.6 ± 1.73
BG/K**	28.3 ± 6.38 B	15.0 ± 3.07
BG/PB	17.7 ± 7.68 AB*	12.6 ± 5.24 NS
CRP average**	20.5 ± 6.97	12.6 ± 2.13

[a]BG/SO Blue grama/side-oats grama mixtures.
BG/K Blue grama/Kleingrass mixtures.
BG/PB Blue grama/plains bluestem mixtures.
[b]1988 differed from 1989 (**$P < 0.01$, analysis of variance).
[c]Means denoted by the same letter within each column are not different (*$P < 0.05$; NS = not significant; $P < 0.1$, analysis of variance).

Table 5. Comparison of ring-necked pheasant nesting results from studies in the Texas Southern High Plains.

Reproductive parameter	This study	Taylor (1980)
Nest success	22%	24%
Abandonment	16%	15%
Clutch size		
Year 1	11.9	9.1
Year 2	10.2	6.9
Average	11.2	8.0
Egg fertility		
Year 1	92%	—
Year 2	90%	—
Average	91%	93%
Nest initiation peak		
Year 1	22–28 April	29 April–4 May
Year 2	22–28 April	5–11 May
Production	1.41 chicks/acre	0.53 chicks/acre
Recruitment		
Fall male population	0.35/acre	0.13/acre
Spring hen population	0.20/acre	0.08/acre
Spring hen density	131/square mile	50/square mile

and small grain habitat. Nest abandonment in CRP was comparable with the overall rates determined for the area in 1979 and 1980 (Table 5).

The overall nest success of 22 percent on CRP lands is considered inadequate to meet pheasant recruitment needs for many areas of the U.S. (Gates et al. 1970, Trautman 1982). However, high nest densities (Table 3), brood survival (Shupe 1984), and hen survival (Snyder 1985) of the area offset this, given the high densities of pheasants present in the SHP (Berthelsen et al. 1989).

Nest Density

Similar pheasant nest densities among CRP cover types in 1989 may be a reflection of BG/SO mixtures becoming higher quality nesting habitat than in 1988. BG/SO mixtures often required extensive landowner management in the first two years to become established. Increased habitat quality of BG/SO in 1989 was demonstrated by increases in nest success (Table 1) and nest density (Table 3) over 1988 results.

CRP Vegetative Profiles

Vegetative characteristics beneficial to pheasant broods are difficult to quantify. Shupe (1984) reported that vegetative structure was the major factor influencing habitat use by broods in the Texas SHP. Habitat preferred by broods in this study area provided more than 95 percent visual obstruction to a height of 8 inches (2.0 dm) and more than 18 percent visual obstruction at 3 feet (1 m) (Shupe 1984). The CRP cover types consistently produced vegetative structure beneficial to pheasant broods (Table 4). Prior to CRP, broods in the Texas SHP relied on playa lake basins, weedy areas, and roadsides as sources of cover (Shupe 1984). Vegetative structure produced by CRP may provide large increases in pheasant brood cover and positively influence survival (Berthelsen et al. 1989).

Production and Recruitment Estimates

Prior studies in the Texas SHP reported high survival rates for pheasant broods. Shupe (1984) estimated 74 percent chick survival to 10 weeks of age, with an average mortality of two chicks per brood. These estimates are higher than the survival rates employed in this study (50 percent) for production and recruitment estimates. Therefore, we provide conservative production estimates. Twenty-four percent of the land enrolled in the Texas SHP through the sixth CRP sign-up contained the grass mixtures studied for pheasant nesting (Berthelsen 1989). Production and recruitment estimates were not applied to the entire area due to wide differences in pheasant populations among areas (Guthery et al. 1980). It is apparent that the large increases in nesting, brood and winter habitat will provide benefits to pheasants and other wildlife throughout the Texas SHP.

Taylor (1980) estimated a pheasant production of 76,425 chicks on 142,862 acres (57,816 h) of playa lake and wheat habitat in Castro County. Taylor's (1980) chick production values, and the survival assumptions applied to pheasants in this study, produced a recruitment of 0.13 males/acre (0.32 males/h) in fall, 0.08 females/acre (0.20 females/h) in spring, and a spring hen density of 50 hens/square mile (31 hens/km^2) for playa lake and wheat habitat alone (Table 5).

Comparison of pheasant production and recruitment between this study and Taylor (1980) (Table 5), provides a method of evaluating the influence of the CRP on pheasants in the area. The increase in pheasant production and density in 1988 and 1989 over 1979 and 1980 estimates is similar to past pheasant responses from some Federal agricultural programs (Berner 1988). Spring hen density estimates on CRP lands in the SHP exceed the average hen densities in the primary pheasant range of North America (Dahlgren 1988).

Relatively mild winters and increases in winter habitat (Berthelsen 1989) may produce hens entering the breeding season in better physiological condition than their northern counterparts. Many studies have determined the adverse effects of winter length and severity on hen survival and reproductive effort (Gates and Woehler 1968, Penrod et al. 1986, Peterson et al. 1988). By increasing dispersal, production and survival, CRP in the Texas SHP may positively influence the primary mechanisms limiting pheasant abundance (Warner 1988).

Conclusions and Management Implications

Blue grama/Kleingrass mixture cover types produced fields of high-quality nesting habitat. This cover type produced high values for: (1) the number of avian nests located, (2) overall nest densities for waterfowl and passerines (Berthelsen 1989), (3) nest success for pheasants (Table 1), (4) overall nest densities for pheasants (Table 3), (5) pheasant production (Table 2), and (6) vegetative structure (Table 4). BG/SO and BG/PB were also good pheasant habitat.

The quality habitat produced by CRP lands will enable pheasants to distribute from formerly concentrated habitats that were often unsafe due to flooding (Taylor 1980), and agricultural practices (Whiteside 1983). Increased sources of large-scale, quality habitat affords greater survival and distribution of pheasants (Warner 1988). Adult survival is considered the most important factor to increasing pheasant numbers (Gates 1971).

General guidelines for managing pheasants, and the CRP in the Texas SHP have been proposed (Schramm et al. 1987). The implementation of secure nesting and winter cover in association with large and small grain crops will supply the most critical pheasant habitat requirements (Whiteside 1983). Increased pheasant numbers will produce economic returns to both landowners and communities in the form of hunting leases (Bryant and Smith 1988) and stimulus to local economies (Harmon 1988).

Increased pheasant production in the SHP due to the CRP will allow for changes in the current pheasant hunting regulations. The Texas SHP has had a two-week pheasant hunting season with a two-bird-per-day bag limit since 1958 (Guthery et al. 1980). Attempts to liberalize the regulations have been unsuccessful. Many studies have demonstrated that hunting season length has little influence on pheasant populations (George et al. 1980). There is little chance of over-harvesting pheasants because of their polygamous nature (Trautman 1982), hunting mortality is probably compensatory (Burnham and Anderson 1984), and high pheasant production in the area. With the results of this study, recommendations are to start the hunting season by 1 November with a 40 to 60 day season (Edwards 1988).

Achieving wildlife benefits from the CRP is dependent on vegetative cover management practices and political pressures. In this study, one-third of the fields selected for nesting study were hayed, or mowed for weed control. These fields had "good" stands of grass according to recommendations of Dahl et al. (1986). When vegetative cover is removed under these practices, CRP lands produce no practical benefits for wildlife (Harmon 1988). Mowing of CRP fields with good grass stands for weed control is unnecessary, and as CRP stands age, grasses will out compete the weeds. In addition, weed control may reduce the compositional quality of the stand (Higgins et al. 1988), decreasing wildlife benefits.

The frequency in which political pressures open CRP lands to haying and grazing is cause for concern. The implementation and continued use of the conservation provisions provided for by law are necessary to achieve full wildlife benefits from the CRP. A CRP program that is properly enforced and managed will produce benefits to a wide range of wildlife. Pheasants, in particular, will benefit from increases in secure, high-quality nesting and winter cover by increased production, rates of dispersal and survival.

The unique combination of high CRP contract density, mild winters and high pheasant populations are greatly increasing pheasant production in the Texas SHP (Berthelsen 1989). Habitat and population characteristics in the Texas SHP provide a chance to study a unique pheasant population. Areas recommended for future research include: (1) adult pheasant survival rates; (2) winter habitat in relation to the CRP; (3) rates of innate dispersal; and (4) influence of CRP cover stand age on pheasant production.

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Evaluating Potential Effects of CRP on Bobwhite Quail in Piedmont Virginia

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Introduction

The Conservation Reserve Program (CRP), authorized by the Food Security Act of 1985, provides payments to farmers for placement of highly erodible croplands into permanent cover for a contract period of at least 10 years. A variety of herbaceous or woody covers may be planted under this program. Because this program has idled 34 million acres of previously cultivated land, there is great potential for improving habitat for wildlife on agricultural lands. Issacs and Howell (1988), Farmer et al. (1988), Jahn (1988), and Hays et al. (1989) recently have discussed the potential for lands placed into CRP to improve habitat for wildlife on farmlands. Miller and Bromley (1989) found that 72 percent of sampled farmers enrolled in CRP in Virginia were interested in improving habitat for wildlife on their lands. Thus, even as demands increase on wildlife habitat, opportunities may exist for the improvement of habitat for at least some species of wildlife.

Throughout the Southeast, the bobwhite quail (*Colinus virginianus*) is an important gamebird. However, quail have declined substantially across the southeastern states and in Virginia over the past 10 years (Flather and Hoekstra 1989). Because bobwhite are associated with agricultural lands, this species may stand to benefit from the CRP. We have been studying bobwhite quail in Piedmont Virginia since 1986. Cline (1988) initiated research to establish baseline information on large-scale quail-habitat relationships on agricultural lands; this work has been continued to assess effects of CRP on quail habitat and to conduct field tests of the Habitat Suitability Index Model for quail (Schroeder 1985). The purpose of this paper is to assess potential effects of CRP on quail by using a model developed from empirical data to simulate potential effects of CRP on quail.

Study Area

This study was conducted on a 56,810-acre (23,000 ha) area in southwestern Halifax County, Virginia. This area is typified by gently rolling landscapes ranging from 300–600 feet (90–180 m) elevation. Approximately 50 percent (256,000 acres [104,000 ha]) of the county is active farmland. Pastureland of all types totals 39,155 acres (15,852 ha). Common crops include corn (9,346 acres [3,784 ha]), wheat (8,662 acres [3,507 ha]), tobacco (9,569 acres [3,874 ha]), soybeans (9,265 acres [3,750 ha]), and hay (9,722 acres [3,936 ha]). Woodlands account for approximately 128,440 acres (52,000 ha) of the county; common tree species include oaks (*Quercus* spp.), hickories (*Carya* spp.), ashes (*Fraxinus* spp.), yellow poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), and pines (*Pinus* spp.). Of 3,353 acres (1,358 ha) of cropland in Halifax County that have been converted to Conservation Reserve, 40 percent of the acreage has been placed into CP1 (permanent introduced grasses and legumes) and 51 percent has been converted to CP3 (tree planting). Primary species planted in CP1 were tall fescue or orchard grass mixed with either clover or lespedeza; loblolly pine (*Pinus taeda*) was the only tree species planted in CP3.

Methods

The sampling units in this study were 121 sampling stations located at 0.5 mile (0.8 km) intervals on 10 transects. The transects were located along roads in a manner to maximize the habitat diversity encountered during sampling. Quail populations were censused along transects using the call-count technique (Rosene 1969). Censuses were conducted from mid-April through mid-July during early morning hours. We censused one transect each morning, stopping at each station for 10 minutes and recording very quail heard or seen calling. These data allowed calculation of an index of quail density (birds/station/run).

We assumed that under most conditions we did not hear quail beyond 0.25 mile (400 m) and thus mapped all habitats within a 0.25 mile radius of each sampling point. Percent cover and associated edge characteristics of 44 cover types were determined for each of the 124 acre (50.2 ha) sampling areas (Cline 1988). For data from 1986 and 1987 we used stepwise multiple regression to develop a model that related the indices of quail density to habitat characteristics within each of the 121 sampling sites.

The multiple regression procedure resulted in a model ($p < 0.001$, $R^2 = 0.45$) that contained six variables that influenced the quail population index within the sampling stations. The resulting model was: Quail index = 2.17 − 0.88 × (proportion of forest-heavy understory) − 1.29 × (proportion of forest-light understory) − 5.31 × (proportion of young [8–15 years] pine plantations) − 2.78 × (proportion of yards) + 3.66 × (proportion of minor cover types) + 1.55 × (proportion of fallow fields). An implicit assumption of this model is that the quail index used is positively correlated with the true underlying quail population density. We believe that this holds for the 124-acre (50.2 ha) sampling units we used. A second assumption is that a higher quail index (i.e., higher population) indicates a higher habitat quality. Again, we believe that this is a reasonable assumption for our application of this model (but *see* Van Horne 1983).

We used this model to predict the quail population index for simulated changes in cover at 107 stations where more than 5 percent (6.2 acres [2.5 ha]) of the station area consisted of cropland. We assumed that these stations represented sites where cropland might potentially be enrolled in CRP. For each station we calculated a baseline value for the quail index based on average cover for 1986 and 1987 with no cropland placed into CRP. Once the baseline values were established, we wanted to evaluate the quail index when portions of the existing cropland were converted to CRP.

Because CP1 and CP3 were the dominant conservation practices on our study area, we simulated conversion of cropland to these two types. Cropland was considered to be fields that were actively cultivated for the growing of crops (pastures were excluded). In the multiple regression model, we used the variable "fallow fields" as a surrogate for CP1. Cropland converted to CP1 should resemble fallow fields for the duration of the 10-year contract, especially in the early years. CP3 was assumed to be equivalent to fallow fields for the first four to seven years of the contract period while pines are in the seedling stage. Towards the end of the contract period (after 7 years) the young pine plantation variable was used as a surrogate for CP3.

We simulated changes of cropland to CRP on the sampling stations in two ways. First, we calculated the quail index for each station if 5, 10, 20, 40, 60, 80, and 100 percent of the existing cropland at each station was converted to CRP. Second, we determined the quail index for stations when 2.5 (1), 5 (2), 9.9 (4), 14.8 (6), 19.8 (8), 24.7 (10), 37 (15), 49.4 (20), and 61.8 (25) acres (ha) of existing cropland were converted to CRP. (Stations that had less cropland than a simulated level of conversion were not analyzed for that and higher levels of crop conversion.) Four different combinations of CP1 and CP3 were simulated: 100 percent of converted cropland into CP1; 67 percent to CP1 and 33 percent to CP3; 33 percent to CP1 and 67 percent to CP3; and, 100 percent of converted cropland into CP3. Thus, the quail index was determined for each station for 64 different scenarios.

In the presentation of results, the quail index under various levels of conversion to CP1 represent expected effects of CP1 throughout the 10 year contract period and for the first 4–7 years of the contract period for CP3. All simulations with CP3 present (33, 67 and 100 percent) represent expected values of the quail index more than 7 years after enrollment of the cropland into the CRP.

The simulated quail indices were analyzed in relation to the level of cropland (low, 5–20 percent crop; medium, 21–40 percent crop; high, more than 40 percent crop) and wooded cover (low, less than 25 percent wooded; medium, 25–50 percent wooded; high, more than 50 percent wooded) at each station. For all data combined and at each crop or wooded level we conducted analyses of variance to test the hypotheses of no difference in the quail indices as increasing amounts (percentage or unit changes) of cropland are converted to CP1 and(or) CP3. We used a multiple range test to determine the least significant (experimentwise alpha = 0.1) difference necessary to declare the quail index at two different levels of CRP conversion significantly different. For each wooded and crop level and CP1–CP3 combination we substituted the least significant difference into the regression equation to determine the threshold of change necessary to elicit a detectable (at $p = 0.1$) change in the quail index.

Results

Overall, about 27 percent of the area in the 124-acre (50.2 ha) units used in the simulations was composed of cropland (Table 1); cover of cropland ranged from 5.5 to 71 percent. Cover of woodlands in the sampling areas varied from 0 to 78 percent. Areas with low and medium crop coverages had relatively high coverage of wooded habitats, whereas stations with high coverage of crops had low forest cover (Table 1). Conversely, stations classified as having low and medium forest cover had relatively high proportions of cropland and highly wooded stations had relatively low crop coverage.

Percentage Changes to CP1 and CP3

The simulation results indicated that when the cropland converted to CRP is placed only into CP1 that the overall quality of the habitat for quail (as indicated by the

Table 1. Mean composition of variables used in the regression model to predict quail response to changes in land use brought about by CRP for various crop and wooded levels. Values represent percentage of 124 acre (50.2 ha) sampling areas composed by each cover category in Halifax County, Virginia.

		Percentage cover (SE)						
						Forest		
Data class	n	Crop	Yard	Fallow	Other	Pole	Open understory	Closed understory
All stations	107	27.0 (1.4)	3.8 (0.3)	9.0 (0.7)	0.8 (0.2)	0.3 (0.1)	16.3 (1.6)	20.0 (1.7)
Crop levels								
Low	41	12.7 (0.7)	4.2 (0.6)	4.7 (0.5)	0.2 (0.1)	0.2 (0.1)	18.9 (2.9)	20.2 (2.8)
Medium	42	28.6 (0.8)	3.4 (0.4)	8.8 (0.8)	0.9 (0.4)	0.5 (0.2)	16.0 (2.6)	24.1 (2.9)
High	24	48.7 (1.6)	3.9 (0.7)	16.7 (1.8)	1.3 (0.6)	0.5 (0.1)	12.2 (2.3)	12.5 (2.2)
Wooded levels								
Low	31	31.8 (3.4)	4.1 (0.7)	8.4 (1.6)	1.1 (0.5)	0.6 (0.2)	7.6 (1.3)	7.5 (1.5)
Medium	53	27.9 (1.7)	4.0 (0.5)	9.9 (0.9)	0.7 (0.3)	0.2 (0.1)	16.5 (1.9)	22.0 (1.9)
High	23	18.4 (1.5)	3.1 (0.6)	7.7 (0.8)	0.4 (0.2)	0.4 (0.1)	27.5 (4.9)	32.2 (4.9)

quail index) increases (Figure 1). The increases noted were directly proportional to the percentage of cropland that was converted; this pattern held for all crop and wooded levels. Habitat quality at all percentages of conversion within stations were highest for high crop areas and lowest for low crop; conversely, habitat quality was greatest for low wooded areas and was lowest for areas with high woods. For all stations combined, the model predicted an average of 32 percent of the existing cropland would have to be converted to CP1 before a detectable increase ($p < 0.1$) in the quail index would be affected (Table 2). At low crop and high woods levels, a large proportion (73–79 percent) of the existing cropland would have to be converted before quail populations might increase noticeably. At high and medium crop levels and low and medium wooded levels a smaller percent conversion to CP1 would result in a detectable difference (Table 2).

When 67 percent of the cropland was converted to CP1 and 33 percent to CP3 the positive influence of CP1 was countered by the negative effect of CP3 after seven years in the contract period (Figure 1). (For about the first five to seven years the effects of CP3 should be similar to those of CP1.) On average, at least 50 percent of the existing cropland would need to be converted before any difference would be noted (Table 2). At low crop levels and high wooded levels, converting all the existing cropland would not be sufficient to appreciably alter the quail index (Table 2). Thus, in areas with low crop, this mixture of CP1 and CP3 is not likely to influence the overall habitat quality for quail. Where relatively large proportions of cropland are converted to 67 percent CP1 and 33 percent CP3 at high and medium crop levels and low and medium wooded levels a slight decline in habitat quality is expected.

At a 1:2 ratio of CP1 to CP3, we noted a substantial decline in quail habitat quality (at more than 7 years) as greater proportions of cropland were converted for all scenarios considered (Figure 1). At high wooded levels and low crop levels, 30 and 42 percent, respectively, of the cropland would have to be converted to bring about a detectable decline in the quail index. At the other levels, a conversion of less than 21 percent might bring about a change (Table 2).

When 100 percent of the converted croplands are placed into CP3, our simulations indicate a substantial negative effect by year 10 (Figure 1). Depending on the level of a crop or wooded cover, conversion of 7 to 25 percent (Table 2) of the cropland would result in a detectable decline in the quail index once the CP3 cover is 8–10 years old. As higher proportions of cropland are converted to CP3 the effect is more pronounced on stations with high crop coverage than those with low coverage (Figure 1). This is primarily a result of the lesser amount of cropland that is available for conversion on the low crop stations.

Unit Changes to CP1 and CP3

The patterns in the expected change in quail habitat quality when specified acreages of cropland were converted paralleled those noted for percentage changes (Figure 2). When 100 percent of the conversion was to CP1, our simulations again indicated a positive effect on quail (Figure 2). When crops are converted only to CP1, it would take a change of at least 10.9 acres (4.4 ha) to bring about a detectable change (Table 2). For stations with more than 50 percent wooded cover, at least 24.9 acres (10.1 ha) would have to be converted to bring about a change. Threshold levels for other wooded and crop levels fell between these two extremes (Table 2).

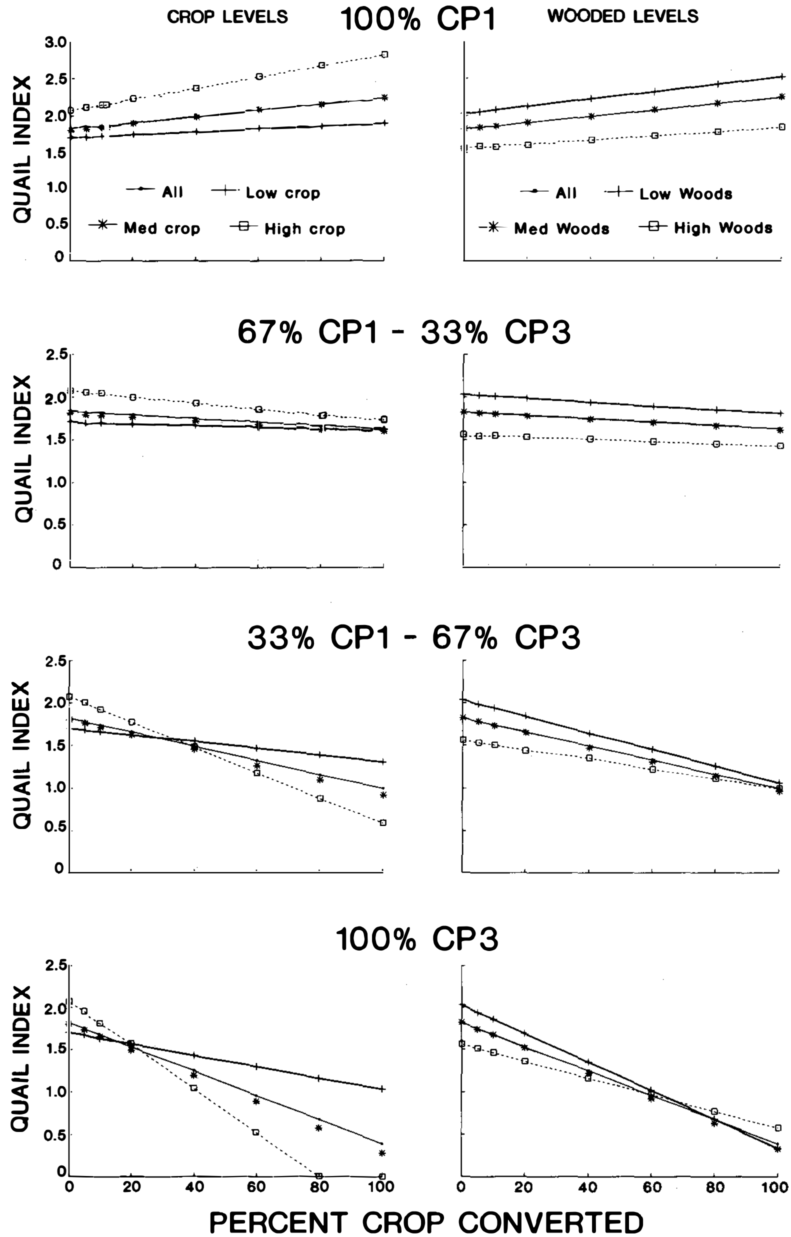

Figure 1. Simulated responses of the quail population index (as an index to habitat quality) to various percentage conversions of existing cropland to different combinations of CP1 (introduced herbaceous cover) and CP3 (pines) in 124 acre units. Trends are plotted for all data and three levels of wooded and crop cover in the simulated units. Index values for 100 percent CP1 would be expected throughout the 10 year contract period. Index values when CP3 (33, 67 and 100 percent) is included are those expected when the pines reach at least eight years of age.

Table 2. Predicted threshold levels in the percentage or unit conversion of cropland to CRP lands necessary for a detectable ($p < 0.1$) change in quail population indices to be noted. Index changes based on 100 percent CP1 (and CP3 up to seven years) may be expected throughout the set-aside period (10 years). Threshold levels for conversions with CP3 are expected when the CP3 is at least eight years old.

	Percentage crop threshold				Unit (acre [ha]) crop threshold			
Data class	100% CP1	67% CP1–33% CP3	33% CP1–67% CP3	100% CP3	100% CP1	67% CP1–33% CP3	33% CP1–67% CP3	100% CP3
All stations	32	50	13	10	14.6 (5.9)	29.6 (12.0)	6.7 (2.7)	4.0 (1.6)
Crop levels								
Low	79	181	42	25	14.8 (6.0)	30.6 (12.4)	7.4 (3.0)	4.2 (1.7)
Medium	31	60	16	9	10.9 (4.4)	23.2 (9.4)	5.4 (2.2)	3.2 (1.3)
High	22	39	10	7	13.1 (5.3)	28.7 (11.6)	6.7 (2.7)	4.0 (1.6)
Wooded levels								
Low	44	59	21	21	15.8 (6.4)	33.6 (13.6)	7.9 (3.2)	4.4 (1.8)
Medium	33	46	14	12	11.1 (4.5)	22.5 (9.1)	5.2 (2.1)	3.0 (1.2)
High	73	129	30	20	24.9 (10.1)	32.9 (13.3)	11.9 (4.8)	7.2 (2.9)

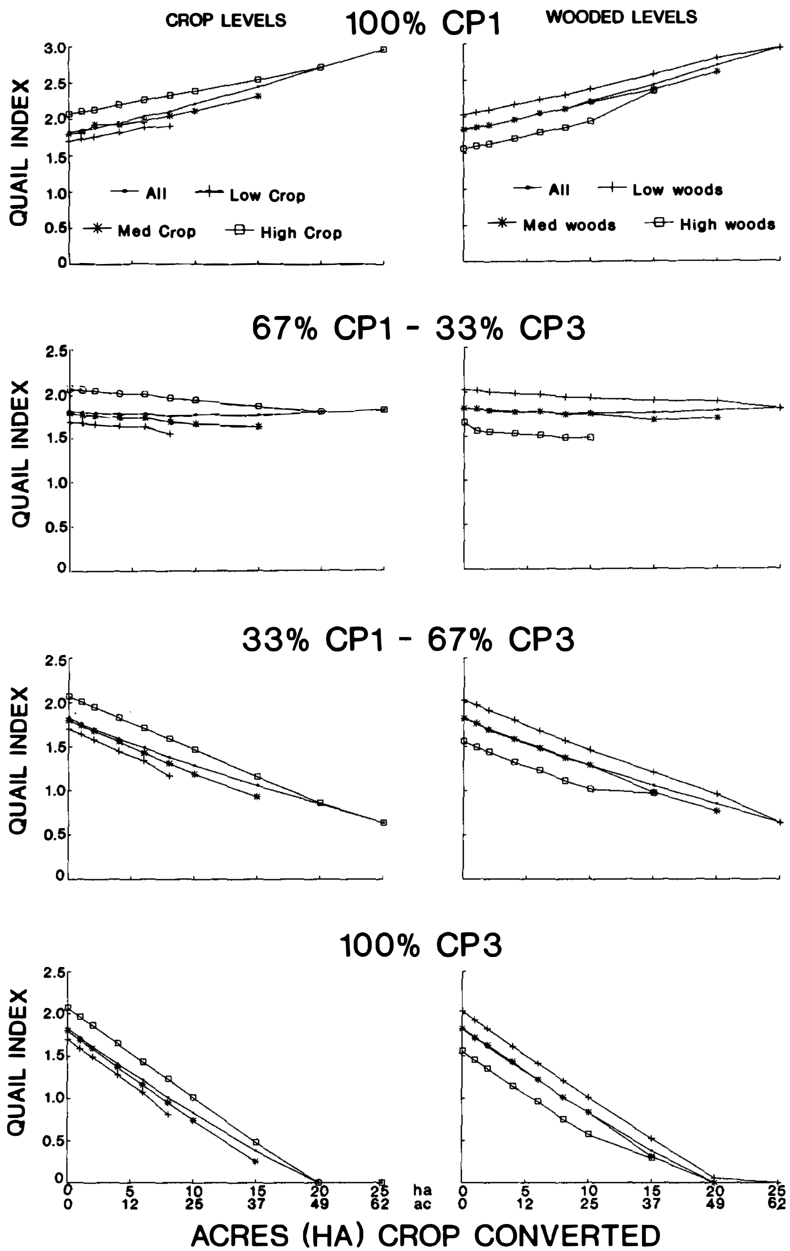

Figure 2. Simulated responses of the quail population index (as an index to habitat quality) to various unit conversions of existing cropland to different combinations of CP1 (introduced herbaceous cover) and CP3 (pines) in 124 acre units. Trends are plotted for all data and three levels of wooded and crop cover in simulated units. Index values for 100 percent CP1 would be expected throughout the 10 year contract period. Index values when CP3 (33, 67 and 100 percent) is included are those expected when the pines reach at least eight years of age.

When 67 percent of converted cropland was placed into CP1 and 33 percent into CP3, very few detectable changes were noted (Figure 2). For all data combined and low crop and high wooded levels the quail index did not differ across all levels of conversion ($p > 0.10$). However, our calculations did indicate a threshold level for these three categories of 29.6 (12.0), 30.6 (12.4), and 32.9 (13.3) acres (ha) to effect a detectable change. It appears that the positive influence of CP1 is being countered by the negative effects of CP3.

When 67 percent of the converted cropland is placed into CP3, a pronounced negative trend is noted as greater acreages are placed into CRP (Figure 2). At this ratio of CP1 to CP3, relatively small amounts of farmland converted to CRP (5.2–11.9 acres [2.1–4.8 ha]) within the 124 acre stations would result in a detectable decline in the quail index (Table 2).

When all the converted farmland is placed into CP3 the simulations indicate that a substantial decline will be noted at 7 to 10 years with minimal acres converted (Figure 2). With all CP3, only 3.0 (1.2) to 7.2 (2.9) acres (ha) would be needed to bring about a detectable decrease in the quail index (Table 2).

Discussion and Implications

Our results indicated that the conversion of cropland to CP1, permanent introduced herbaceous cover, is likely to have a positive effect on the quality of quail habitat if enough cropland (11–20 acres [4.4–8.1 ha] per 124 acres [50.2 ha]) is converted. CP1 may be beneficial to quail by providing cover that may be used throughout the year for nesting, brood-rearing and feeding. Berthelsen et al. (1989) determined that CRP lands, primarily CP1 and CP2 (permanent native grasses), will benefit pheasant (*Phasianus colchicus*) populations by increasing nesting, brood and winter cover in Texas. Similar results might be expected for quail. However, the beneficial effect of CP1 is likely to be maintained only while a suitable grass-forb mixture is maintained. If grasses such as tall fescue dominate and form dense sod, positive effects are likely to be reduced.

The simulations also suggest that, as greater amounts of cropland are converted to CP3, the quality of habitat for quail will decline substantially. For the first five to seven years after conversion, CP3 fields will resemble CP1 and fallow fields. Thus, the early stages of CP3 should be beneficial for quail in a manner similar to that of CP1. However, once the pines mature and the canopy begins to close, the quality of the habitat declines substantially. These areas will have minimal understory cover for nesting and brood-rearing and provide little food suitable for quail (Sweeney et al. 1981). Thus, the pattern on lands placed into CP3 within relatively small units (124 acres [50.2 ha]) is likely to be one of an initial increase in the quality of quail habitat followed by a decline in habitat quality to a level below that of the previous habitat conditions.

Generally in our study area, the higher quality quail habitat existed on areas where crop levels were highest (Figures 1 and 2). This may be a result of greater habitat diversity (even the areas with high crop levels had substantial forest cover, Table 1) than that found where forested habitats dominated. These more diverse areas provide the foraging, breeding and resting needs of quail (Stoddard 1931, Hanson and Miller 1961, Rosene 1969, Klimstra and Roseberry 1975). The greatest opportunities for improving quail habitat through CRP probably exist on areas with higher levels of cropland. On these areas, a smaller absolute amount of cropland converted to CP1 was needed to elicit a noticeable improvement in the quail index than on areas with less cropland and greater forest cover.

The model we used for the simulations did not consider the spatial relationships among the various habitats present on the sampling areas. The juxtaposition and interspersion of habitats necessary to provide for the needs of quail should be considered when planning and implementing various conservation practices (Roseberry and Klimstra 1984). When the conversion of cropland to CRP increases the overall habitat diversity within an area and adds components previously lacking (such as nesting and brood-rearing cover provided by CP1), we can expect to see an increase in quail populations. Conversely, when overall diversity is reduced, quail populations are likely to decline. The large amount of CRP being placed into CP3 is likely to cause substantial local declines in quail populations. In our study area and throughout the Piedmont, cover of woody vegetation is relatively high (e.g., 36 percent on our study area). On these areas, addition of woody cover in the form of pine plantations will lower overall habitat diversity with a concomitant decline in quail populations.

The results of our simulations are based upon a regression model developed from data measured at a relatively gross scale (124-acre [50.2 ha] plots). Our predictions are accurate to the extent that land converted to CP1 actually resembles fallow fields and that CP3 is equivalent to pine plantations. We believe that, at least for the first several years of the contract period, CP1 has the cover characteristics typical of fallow fields (e.g., *see* data in Hays et al. 1989). CP3 planted to loblolly pine is equivalent to our pine plantation variable once the fields attain seven to eight years of age. Thus, we feel secure in our evaluations of the general effects of cropland being converted to CP1 and CP3, in terms of expected increases or decreases in quality of quail habitat. It is important to recognize that there are other conservation practices (e.g., CP4-permanent wildlife habitat, CP12-wildlife food plot) available that we did not include in our model. These practices are likely to be implemented on a relatively small scale, but have the potential to have a substantial positive impact on quail populations if planned to supplement limiting factors and to increase overall habitat diversity. USDA personnel responsible for planning and implementing CRP practices should be encouraged to consider these alternative conservation practices.

Our model accounted for 45 percent of the variation in quail population indices; this implies that more than half of the variation in quail populations is not explained by the coverage of various habitats on agricultural lands. Other factors also impinge on quail populations. Some of these factors, such as weather, cannot be managed. However, as the Conservation Reserve Program is implemented, consideration needs to be given to aspects such as the juxtaposition and interspersion of CRP fields (see above). Also, a large amount of cropland converted to CRP may not be beneficial if large fields are converted; more habitat diversity will be created by converting many smaller fields rather than one large field. The presence and timing of mowing on CP1 may have a substantial impact on the overall quality of the area and should be monitored closely. Additionally, the use of agricultural chemicals, either before the set-aside period or on adjacent lands, may be impacting quail populations (Stinson et al. 1989). In conclusion, the Conservation Reserve Program appears to have potential to improve, primarily through the use of CP1 (and potentially similar practices such as CP2, CP4, CP11, CP12 and CP13), the quality of quail habitat in

Piedmont Virginia. However, management plans to improve quail habitat should not rely solely on the CRP; rather, the CRP should be one of several tools integrated to maximize the probability of success in quail management.

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New Mexico's CRP and Wildlife Habitat Improvement

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Introduction

The 1985 Food Security Act creates the largest change in land use in the United States since the 1930s. The primary purpose of this Act is to reduce the overabundance of grain crops and to address the ever-increasing problem of soil erosion. Coincidentally, this Act also offers opportunities for wildlife management on farmlands and attempts to resolve the conflict between agriculture and a most important wildlife habitat—wetlands.

The Food Security Act of 1985 contains five major provisos, commonly referred to as the "conservation provisions." The most controversial of these—the so-called Swampbuster provision—discourages the conversion of wetlands to agricultural production. As stated in the Act, any operator who produces an agricultural commodity on wetlands converted after December 23, 1985, becomes ineligible for most federal farm programs, including loans, subsidies, crop insurance and price-support programs.

The Sodbuster provision is intended to reduce the conversion of highly erodible lands to agricultural production. Under this provision, any operator who produces an agricultural commodity on highly erodible lands after December 23, 1985, becomes ineligible for federal farm programs, unless the operator farms the land under a Conservation Plan approved by the local Soil and Water Conservation District.

The Conservation Set-aside provision authorizes the Secretary of Agriculture to grant partial debt relief to farmers in return for a conservation easement on selected portions of their farms. The objective of the provision is to assist financially beleaguered farmers in debt to the Farmers Home Administration (FmHA).

The Conservation Easement provision authorizes the Secretary of Agriculture, acting through FmHA, to grant or sell easements for conservation purposes on FmHA

Surplus Inventory Lands. These easements can be granted to state or local government agencies and private, nonprofit organizations.

The final provision of the Act—the Conservation Reserve Program—is intended to encourage farmers to take designated highly erodible land out of production to help reduce surplus production. Under a 10-year contract with the Department of Agriculture, a farmer would receive annual rental payments for land on which he applies certain soil-conservation procedures. These procedures can include planting grasses, forbs, shrubs and trees for wildlife cover and food. Wetland-development projects can also be initiated.

The Conservation Reserve Program in New Mexico

New Mexico is essentially a high, arched plateau that averages about 7,000 feet in elevation in the north to 3,500 feet in the south and east. The state is very arid, receiving less than 20 inches average precipitation per year, with many of its plant communities drought resistant, yet fragile and highly susceptible to misuse. The eastern portion of the state marks the westernmost extension of the Great Plains grasslands, a region of open vistas, rolling grasslands and meandering rivers. It also is the area of New Mexico that is the most intensively farmed.

With the advent of the 1985 Food Security Act, many public entities, including fish and wildlife agencies, focused their attention on the eastside farm belt. In 1987, the New Mexico Department of Game and Fish, the U.S. Fish and Wildlife Service (Service), the New Mexico State University Cooperative Extension Service, and the U.S. Soil Conservation Service met and discussed a cooperative venture for enhancing wildlife habitat, using the conservation provisions of the 1985 Food Security Act as an instrument for initiating their plan. They agreed from the outset that the plan could only succeed with a wildlife biologist stationed in the area to develop trust with landowners. Accordingly, each agency financially supported the biologist, formally titled Interagency Biologist, and stationed him in the heart of New Mexico's Conservation Reserve Program area. The biologist's task is to meet with individual landowners and discuss what they can do for wildlife by modifying their Conservation Reserve Program contracts.

The majority of land in the Conservation Reserve Program in New Mexico has been planted with grass species because of government deadlines and economics more than any other factor. However, under the provisions of the 1985 Food Security Act, the type of cover can be modified to benefit wildlife. Accordingly, the Interagency Biologist discusses proposed modifications with landowners and suggests varieties of trees, shrubs and forbs that would be more beneficial to wildlife than homogeneous stands of grass would be.

Not only must the Interagency Biologist meet with the Conservation Reserve Program Landowners and promote management for a wide variety of wildlife, but he must also satisfy each of his supporting agencies. Although all the agencies have the best interests of wildlife in mind, their priorities may differ. For example, the Fish and Wildlife Service is primarily interested in the management of Conservation Reserve Program lands for waterfowl. It is attempting to comply fully with President Bush's pledge that ". . . wherever wetlands must give way to farming or development, they will be replaced or expanded elsewhere. It's time to stand the history of wetland destruction on its head: From this year forward, anyone who tries to drain the swamp is going to be up to his ears in alligators. . . ." Since eastern New Mexico has wet depression areas, commonly called playa lakes, the Service is interested in encouraging landowners to manage their playas for maximum benefit to waterfowl, whether it be by planting wildlife food or cover around the playa area or supplementing water to a playa during periods of drought.

In contrast, the New Mexico Department of Game and Fish is primarily interested in upland areas, focusing more on measures that will benefit prairie chicken, quail and ring-necked pheasant. Thus, the agency is interested in having the homogeneous grass fields strip-planted with food and cover beneficial to these species. Interestingly, even though these birds spend much of their time in upland areas, some playas also provide food and cover for them, especially during stressful winter seasons.

As one of the cooperators, the New Mexico State University Cooperative Extension Service is interested in having the Interagency Biologist discuss fee hunting with landowners. This agency believes that, by promoting fee hunting on farmland, landowners would begin to manage portions of their land intensively for wildlife species. This principle of managing land for wildlife profit is gaining acceptance by more ranchers and farmers each year.

The Soil Conservation Service, an agency that was instrumental in developing management plans for cooperators in the Conservation Reserve Program, is assisting in modifying these plans for the benefit of wildlife. Conservation plans were first developed by the Soil Conservation Service, when Food Security Act mandated deadlines allowed only those management plans that were the most economical and expedient. Now that landowners have had time to reflect on the plans, the Service is very interested in modifying these plans, at the landowner's option, for the benefit of wildlife.

Accomplishments

The Interagency Biologist was first stationed at Clovis, New Mexico, in May of 1989. After a quick review of the resources, a strategy was developed, in consultation with the agency cooperators, that will be followed for the term of this project. Food and cover plantings, as well as water-development projects, are the driving principles of this habitat-manipulation program. Additionally, Eastern New Mexico University at Portales has become a partner in this undertaking with their studies of wildlife response to habitat changes.

In Curry and Roosevelt Counties of eastern New Mexico, there are 16 sites of food plantings on Conservation Reserve Program land. Strips of milo and millet have been planted within the grasses sown as an original conservation practice. Although only 50 acres of these food crops were planted, they influence hundreds of acres because of their proximity with Conservation Reserve Program lands. These initial plantings are on private farmland. As neighboring farmers learn of the value of this practice for wildlife, many more landowners, we believe, will initiate this practice.

Cover vegetation for wildlife is most important and more difficult to establish than food crops. Because of the "clean" farming practices presently employed in eastern New Mexico, winter cover may be the limiting factor for many species of wildlife, especially birds. Because of this, cover vegetation of value to birds is being intensively promoted, utilizing drip-irrigation systems. Nineteen landowners have installed drip systems to irrigate Russian olive, skunkbush sumac, plains cottonwood trees, sand cherry, native plum, pfitzer and Rocky Mountain juniper, and eastern red cedar. The landowners have planted 15 acres in these habitat types, which influence hundreds of additional acres because of their relationship to Conservation Reserve Program lands.

Another project associated with establishing cover vegetation, although in its infancy, is a fee-hunting cooperative. This hunting cooperative was initiated by the Interagency Biologist and involves 20,000 acres in the Central Curry County Soil and Water Conservation District (District). In exchange for a landowner permitting hunter access, the District would install minor habitat-enhancement projects on the landowner's property.

Water projects, some involving playas, have been developed on numerous parcels of private land. One of these projects provides surface water in areas with shallow watertables. This project was accomplished with the cooperation of the landowner and the New Mexico Department of Game and Fish. Pits were excavated into the watertable with a backhoe, gently sloping the sides to encourage the growth of emergent vegetation as well as use by terrestrial animals. Waterfowl use was also part of the management plan, even though each watered surface is only 30 feet in diameter.

Another interesting project involves the modification of playas to collect water in smaller and deeper locations. These modifications were necessitated by the short duration of water in many playas, due mostly to evaporative loss. Artificial potholes were constructed in six playas to collect water in smaller and deeper areas, thus reducing the high evaporative loss. The artificial potholes were excavated with explosive charges and shaped with machinery. Students at Eastern New Mexico University are observing these modified playas to assess their utility for wildlife. Interestingly, one of the modified playas has a center pivot sprinkler that circles through the area, supplementing water to the pothole.

In addition to construction activities for wildlife water conservation, two water guzzlers have also been placed on private farms. These devices are large (10 feet in diameter) fiberglass water collectors that capture and store rainfall in an enclosed area for use by wildlife. The collectors will sustain themselves in an arid environment with at least 12 inches of rainfall annually. The two landowners have agreed to monitor the guzzlers for their water permanence and use by wildlife. In a more formal study, students from Eastern New Mexico University will also be monitoring the devices for their wildlife utility.

Other Conservation Benefits

The presence of the Interagency Biologist in eastern New Mexico has generated a considerable amount of interest by landowners for wildlife. The biologist's daily contact with landowners and continuous discussion of management options have disclosed opportunities for wildlife management that no one perceived at the beginning of this program. For instance, the current management of a considerable amount of land in eastern New Mexico has produced little benefit for man or wildlife. Typically, each center pivot sprinkler on a quarter section of land (160 acres) has approximately 7 acres of fallow land on each corner. The corners are usually planted in annual vegetation of some kind to conserve soil from wind erosion. Unfortunately, the corners are usually plowed and replanted at certain intervals, precluding permanent vegetative cover or food strips as a management option. However, the cooperative agencies supporting the Interagency Biologist have asked the U.S. Agricultural Stabilization and Conservation Service to investigate the possibility of changing the management of the corners for the benefit of wildlife. In addition to benefitting wildlife, the landowner might profit from wildlife produced on the land or, at the very least, spend less time and labor on repeated treatment of the corners.

In a present Memorandum of Understanding between FmHA and the Service, conservation easements for the benefit of wildlife can be attached to surplus FmHA land prior to their sale. The majority of these surplus lands is located in eastern New Mexico, enabling the Interagency Biologist to become intimately familiar with the land prior to any conservation easement proposal. In some cases, a complete parcel of FmHA land can be transferred in fee simple to a resource agency. A test case of such a parcel is presently under review, prior to its transfer to the New Mexico Department of Game and Fish.

Rainfall harvesting is a passive technique for watering plants that is currently under intensive investigation. This system involves excavating very shallow (6–12 inches) and wide (8–12 feet) ditches and lining them with a heavy gauge plastic. Plants are placed in the bottom of the ditch with the plastic performing two important functions: (1) delivery of rainwater from the lined ditch to the plants; and (2) suppression of competitive vegetation so that the desired vegetative species can become fully established. Approximately three miles of ditch have been established at five different locations, with very promising results. All drip-irrigated plants except four-wing saltbush show more vigor than the rainfall-harvested plants. However, even though the dripped plants are more vigorous, the rainfall-harvested plants are hearty and growing at an acceptable rate. Rainfall harvesting has the advantages of lower cost and higher reliability than drip irrigation. Many biologists believe that this technique may be the future for vegetative planting in arid environments. Rainfall harvesting may be particularly important in playa areas because of the opportunity to benefit from existing natural ground contours.

Prospects for the Future

In 1990, we plan to continue the management items that we initiated in 1989, with the goal of placing twice as many projects on the ground. We have programmed four more guzzlers, 12 more playa blastings, 100 acres of food crops and as many acres of vegetative cover as we can manage, using drip irrigation as well as rainfall harvesting. We have also been studying the feasibility of utilizing sewage treatment water in some playas in the Clovis, New Mexico area, although we have been prevented from studying this management option any further because of lack of funds. However, two recent initiatives may provide monies for the Clovis project as well as other wetland projects in the area. Under the Playa Lakes Joint Venture, a program of the North American Waterfowl Management Plan, contributions by Phillips Petroleum and Ducks Unlimited as well as public agencies, will enable projects associated with playas to be accomplished. On December 13, 1989, President Bush signed the North American Wetlands Conservation Act, which may also provide major funding to our wetland projects in eastern New Mexico.

We believe that it is timely that the Interagency Biologist is in place in the area of New Mexico where much state and national attention may be focused in the near future. We hope we can accomplish much more than the agency cooperators intended in 1987 when we first devised this wildlife program.

Structural Characteristics of Vegetation in CRP Fields in Northern Missouri and Their Suitability as Bobwhite Habitat

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Introduction

The distribution of many wildlife species is dependent on habitat occurring on private farm lands. Most land in the Midwest is privately owned and devoted to agriculture. In 1987, more than 5 million acres (2.0 million ha) in Missouri were devoted to agriculture while only 0.3 million acres (0.12 million ha) were managed for wildlife by state natural resource agencies. Clearly, the fate of farmland wildlife depends on land-use practices on private lands.

Agricultural practices that destroy wildlife habitat are routinely applied to midwestern farmland because the production of wildlife habitat has limited economic value to farmers (Langer 1979). The Conservation Reserve Program (CRP) provision of the 1985 Food Security Act provides economic incentive for farmers to remove highly erodable land from production for 10 years. Although the Conservation Reserve Program is aimed at curtailing production of excess commodities and the cultivation of eroding farmland, large acreages of wildlife habitat could be produced. Nationwide, about 45 million acres (18.2 million ha) will be taken out of production, most of which will be put into a grass or grass-legume perennial cover.

Previous federal cropland diversion programs have provided habitat for a variety of wildlife species (Berner 1988). Peak enrollment in the Soilbank Program of the 1950s coincided with peak pheasant (*Phasianus colchicus*) abundance over portions of the Midwest (Edwards 1984). Other cropland diversion programs benefited upland gamebirds to different degrees (Joselyn and Warnock 1964, Gates and Ostrum 1966, Harmon and Nelson 1973). However, habitat conditions and subsequent population responses were poorly documented.

In Missouri, 1.3 million acres (0.5 million ha) of highly erodable cropland have been enrolled in the CRP through 1988 (USDA Soil Conservation Service, unpublished data 1989). In an effort to maximize the wildlife value of CRP lands, the Missouri Department of Conservation (MDC) offers 25 percent cost share for establishing vegetation considered favorable to wildlife (e.g., native warm-season grasses, grass-legume mixtures, shrubs and trees, or no-till food plots) (Miller et al. 1988). In extensively cultivated portions of Missouri, CRP has the potential to create much needed wildlife habitat on private land.

One species that could benefit from CRP lands in north Missouri is the northern bobwhite (*Colinus virginianus*). The long term abundance of bobwhite is a function of the availability and quality of food, cover, and nesting and brood-rearing habitat (Roseberry and Klimstra 1984, Shroeder 1985). The value of cropland to bobwhite is related to the type of crop, weather conditions, and juxtaposition of suitable cover (Roseberry and Klimstra 1984). Although grain foods benefit quail (Roseberry et al. 1979), expanding cropland at the expense of nesting, brood-rearing and protective cover, is thought to be detrimental (Kabat and Thompson 1963, Exum et al. 1982). Thirty to 40 percent grassland has been suggested as being optimal for bobwhite (Edminister 1954, Shroeder 1985). Where grasslands are limited or lacking, CRP fields could provide essential nesting, brood-rearing, and roosting cover. Moreover, the addition of CRP fields could increase the diversity and interspersion of cover types in farm landscapes.

The bobwhite is one of several species for which habitat conditions on CRP lands are being evaluated through the International Association of Fish and Wildlife Agencies/U.S. Fish and Wildlife Service joint CRP monitoring study (Farmer et al. 1988, Hays et al. 1989). However, the inferences from this study are limited to management recommendations at the regional level. To maximize wildlife benefits on CRP lands, resource managers need quantitative descriptions of vegetation structure that reflect state-level habitat conditions. Such information will enable biologists to make better informed management recommendations throughout the duration of the program and to adapt these recommendations to more localized conditions.

This paper reports first-year results of a long-term study of vegetative conditions on CRP lands in northern Missouri. Although our results have implications for a variety of grassland fauna, this paper concentrates on the value of CRP lands as winter, nesting and brood-rearing cover for bobwhite and provides management recommendations for enhancing these cover requirements.

Methods

We studied the northern one-third of Missouri, an area that contains 69 percent of the state's 1.3 million CRP acres (USDA Soil Conservation Service, unpublished data 1989). We randomly sampled 154 fields, stratified by year of establishment (1986–1988) and conservation practice. The conservation practices evaluated were CP1 (cool-season grasses), CP2 (warm-season grasses), and CP4 (wildlife habitat). Measurements were made in winter (Jan.–Mar.) (n = 154 fields) and summer (June–Aug.) (n = 151 fields). We described each field at two resolutions. Whole field characteristics included dominant vegetation type, cover crop, and type and extent of disturbance. At a finer resolution, we established four permanent plots in each field located at 50 m intervals along a randomly selected transect. Plots were marked with a steel stake driven flush with the ground and a wire flag above ground. We estimated height and density of vegetation with four visual obstruction readings (VOR) taken in the cardinal directions from the center of the plot (Robel et al. 1970). Canopy and ground coverage of grasses, forbs, bare ground, litter and litter depth were estimated within four 0.1 m Daubenmire frames (Daubenmire 1959) oriented in the cardinal directions from the center of the plot. We estimated the relative percent canopy and ground coverage using Daubenmire's seven canopy coverage classes. Cover category values were used in statistical tests of conservation practice and year effects. Categorical measures were converted to estimates of percent coverage by substituting class midpoints (Daubenmire 1959). Within each Daubenmire frame we also measured maximum vegetation height and mean canopy height.

Maximum likelihood Chi-square tests (G-test) were used to compare disturbance among years and conservation practices. Analysis of variance (ANOVA) was used to test for year and conservation practice effects on VOR, vegetation height, canopy cover and ground cover. When we observed a significant F-test ($P < 0.05$) for main effects we tested for differences among levels of that effect with a Tukey-Kramer multiple comparison (Day and Quinn 1989).

Results

Winter

During winter sampling 58 percent of the fields were dominated or codominated by perennial grasses, 40 percent by annual weeds, and 22 percent by legumes. Perennial grasses dominated fields established in 1986 (77.3 percent), whereas annual weeds dominated in 1988 fields (58 percent) (Figure 1). Mowing, presumably to control weeds, occurred on 34 percent of fields, 15 percent were hayed under the 1988 drought disaster relief provision, and 4.8 percent had been disked, plowed or removed from the program. Only 17 percent of hayed fields had been strip-mowed in accordance with Agricultural Stabilization and Conservation Service (ASCS) guidelines; most were hayed in entirety. Conservation practice may have affected the probability of a field being disturbed. Fields enrolled as CP4 were disturbed less often ($G = 4.55$, $DF = 2$, $P = 0.10$) than CP2 or CP1 fields (Figure 2).

The year of establishment and conservation practice affected the height and density of vegetation. VOR estimates were 6.9 cm for 1986 fields, 3.4 cm for 1987 fields, and 1.8 cm for 1988 fields (Table 1). CP2 fields had higher VORs (7.6 cm) than CP1 (2.9 cm) fields (Table 2). We observed similar patterns for maximum vegetation and mean canopy height. Height of vegetation increased with age of field (Table 1), and CP2 and CP4 fields had taller vegetation than CP1 fields (Table 2). Grass canopy and ground coverage also increased as fields aged (Table 1). Conversely, bare ground was most abundant in recently established fields.

Summer

We observed less disturbance during summer sampling than during winter. However, we observed the same pattern of greater disturbance in CP1 fields (Figure 2).

DOMINANT VEGETATION IN CRP FIELDS

DURING WINTER

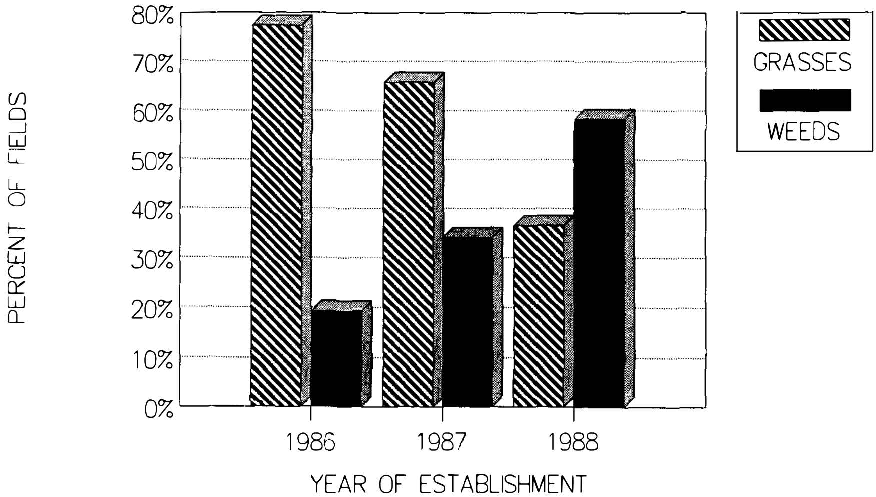

Figure 1. Dominant vegetation types during winter 1989 in northern Missouri CRP fields established in 1986–1988.

PERCENT OF CRP FIELDS DISTURBED

WINTER AND SUMMER 1989

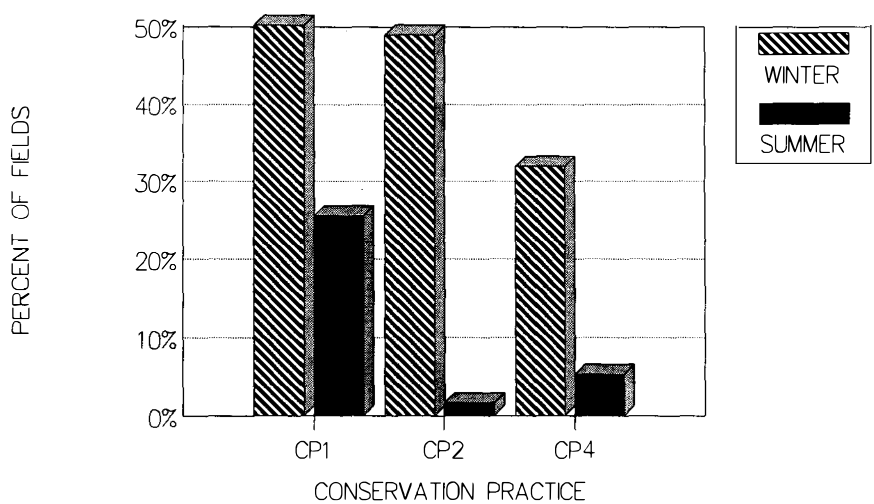

Figure 2. Percentage of CP1, CP2 and CP4 fields disturbed during winter and summer 1989.

Table 1. Mean structural characteristics of vegetation in CRP fields in northern Missouri during winter, 1989, by year of establishment.

Variable	1986 $\bar{x}$[a]	1986 %		1987 $\bar{x}$[a]	1987 %		1988 $\bar{x}$[a]	1988 %	
VOR (cm)	6.9		B	3.4		A	1.8		A
Max height (cm)	46.1		C	35.6		B	24.4		A
Mean height (cm)	20.6		B	13.7		A	9.8		A
Grass canopy[b]	3.1	43	B	3.0	40	B	2.1	25	A
Forb canopy[b]	1.2	11		1.5	14		1.3	11	
Grass ground[b]	2.1	20	B	1.9	19	B	1.3	11	A
Forb ground[b]	1.0	7		1.1	7		1.1	8	
Bare ground[b]	1.3	12	A	1.7	16	A	2.8	36	B
Litter cover[b]	2.8	35		2.8	35		2.6	32	
Litter depth (cm)	2.9			2.6			2.6		

Year of establishment

[a]Means followed by different letters significantly different, ANOVA F-test, DF = 2, 145, P < 0.05, followed by Tukey-Kramer multiple comparison, P < 0.05.
[b]Mean Daubenmire (1959) canopy coverage classes followed by mean percentage of coverage.

Twenty-six percent of CP1 fields were disturbed, whereas only 2 and 5 percent of CP2 and CP4 fields were disturbed, respectively (G = 6.15, DF = 2, P = 0.05). During summer sampling, the dominant vegetation pattern was similar to that observed during the winter. Perennial grasses were dominant in 1986 fields (81 percent) and annual weeds dominated 1988 fields (80 percent) (Figure 3). Of those fields enrolled as CP1, 28 percent were in fescue (*Festuca* spp), 20 percent in orchard grass (*Dactylis* spp.), 11 percent in timothy (*Phleum* spp.), 10 percent in pure legumes, and 3 percent in brome (*Bromus* spp.). In 28 percent of CP1 fields the initial cover crop failed or disturbance precluded determination of the current cover.

Table 2. Mean structural characteristics of vegetation in CRP fields in northern Missouri during winter, 1989, by conservation practice (CP).

Variable	CP-1 $\bar{x}$[a]	CP-1 %		CP-2 $\bar{x}$[a]	CP-2 %		CP-4 $\bar{x}$[a]	CP-4 %	
VOR (cm)	2.9		B	7.6		A	6.1		AB
Max height (cm)	31.4		B	48.9		A	46.3		A
Mean height (cm)	12.1		B	23.1		A	20.3		A
Grass canopy[b]	2.8	37		2.7	35		2.4	31	
Forb canopy[b]	1.3	12		1.5	13		1.7	16	
Grass ground[b]	1.8	17		1.7	14		1.9	21	
Forb groundxb	1.0	7		1.2	7		1.3	10	
Bare ground[b]	1.9	21		1.9	19		1.8	19	
Litter cover[b]	2.8	34		2.7	32		2.9	37	
Litter depth (cm)	2.6			2.6			3.1		

Conservation practice

[a]Means followed by different letters significantly different, ANOVA F-test, DF = 2, 145, P < 0.05, followed by Tukey-Kramer multiple comparison, P < 0.05.
[b]Mean Daubenmire (1959) canopy coverage classes followed by mean percentage of coverage.

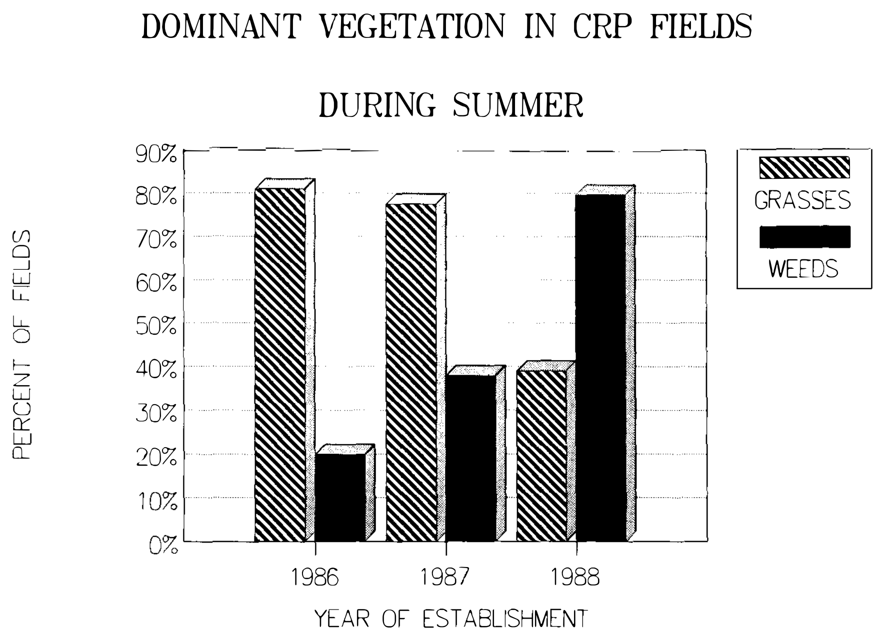

Figure 3. Dominant vegetation types during summer 1989 in northern Missouri CRP fields established in 1986–1988.

VORs were 21.6 cm in CP1 fields, 43.2 cm in CP2 fields, and 39.0 cm in CP4 fields (Table 3). VOR did not differ among years. No conservation practice or year effects on maximum vegetation height were observed. Mean canopy height was higher in CP2 fields (36.9 cm) than in CP1 fields (24.6 cm) (Table 3). Forb canopy coverage differed among conservation practices. CP4 fields had greater forb canopy coverage than CP1 or CP2 fields (Table 3). As observed during winter the amount of grass canopy increased and bare ground decreased with field age (Table 4).

Discussion

Based on the extant literature we can speculate on the ability of CPR lands in northern Missouri to meet seasonal habitat need of bobwhites. Klimstra and Ziccardi (1963) described winter roost cover as having a minimum height of 30 cm. None of the disturbed CRP fields, which comprised 54 percent of the sample, provided roost cover under this criterion. Klimstra and Ziccardi (1963) reported that bobwhite in Illinois most frequently roosted in vegetation 30–90 cm tall. Based on this criterion, more than two-thirds of the undisturbed fields provided winter roosting cover. Similarly, early spring nesting cover was affected by disturbance. An important component of nesting cover is nest concealment. Height of cover at bobwhite nest sites in Illinois averaged 49 cm (Klimstra and Roseberry 1975). Nesting bobwhite are dependent on residual vegetation left standing from the previous growing season (Stoddard 1931, Klimstra and Roseberry 1975, Roseberry and Klimstra 1984). Mow-

Table 3. Mean structural characteristics of vegetation in CRP fields in northern Missouri during summer, 1989, by conservation practice (CP).

	Conservation practice								
	CP-1			CP-2			CP-4		
Variable	$\bar{x}$[a]	%		$\bar{x}$[a]	%		$\bar{x}$[a]	%	
VOR (cm)	21.6		A	43.2		B	39.0		B
Max height (cm)	70.1			80.1			78.1		
Mean height (cm)	24.6		A	36.9		B	29.4		AB
Grass canopy[b]	2.8	39		3.1	43		2.4	28	
Forb canopy[b]	2.0	20	A	2.1	25	A	3.2	44	B
Grass ground[b]	2.1	23		2.3	26		1.7	15	
Forb ground[b]	1.5	13		1.6	14		2.1	23	
Bare ground[b]	2.0	22		2.0	22		2.2	25	
Litter cover[b]	2.9	38		3.0	39		2.6	31	
Litter depth (cm)	2.6			2.7			2.6		

[a]Means followed by different letters significantly different, ANOVA F-test, DF = 2, 142, $P < 0.05$, followed by Tukey-Kramer multiple comparison, $P < 0.05$.
[b]Mean Daubenmire (1959) canopy coverage classes followed by mean percentage of coverage.

ing and haying activities obviously reduce residual vegetation and limit pre green-up nesting cover. Fields we sampled that had been disturbed had mean VORs of only 2–3 cm. Because fields we sampled tended to be completely disturbed rather than mowed in strips or sections, early spring nesting cover was essentially eliminated by disturbance.

Emergency haying of CRP lands as authorized under the 1988 drought relief program was a major component of disturbance and may have contributed to a decline in habitat quality. Only 15 percent of our sample was hayed, however, many of

Table 4. Mean structural characteristics of vegetation in CRP fields in northern Missouri during summer 1989, by year of establishment.

	Year of establishment								
	1986			1987			1988		
Variable	$\bar{x}$[a]	%		$\bar{x}$[a]	%		$\bar{x}$[a]	%	
VOR (cm)	32.8			24.0			23.6		
Max height (cm)	87.1			71.9			61.0		
Mean height (cm)	31.3			25.1			25.5		
Grass canopy[b]	2.9	40		3.0	41		2.4	31	
Forb canopy[b]	2.3	26		2.1	25		2.2	28	
Grass ground[b]	2.2	25	B	2.2	26	B	1.6	15	A
Forb ground[b]	1.7	16		1.5	14		1.4	12	
Bare ground[b]	1.5	12	A	1.8	19	A	2.6	35	B
Litter cover[b]	3.2	43		2.9	38		2.7	34	
Litter depth (cm)	2.6			2.5			2.8		

[a]Means followed by different, ANOVA F-test, DF = 2, 142, $P < 0.05$, followed by Tukey-Kramer multiple comparison, $P < 0.05$.
[b]Mean Daubenmire (1959) canopy coverage classes followed by mean percentage of coverage.

these fields may have gone unmowed if haying was not permitted. Within our sample only 17 percent of the fields were harvested in accordance with the guidelines requiring a portion of the field to remain unmowed to provide wildlife habitat. The remaining 83 percent of the fields were harvested in entirety.

The year of establishment, or age of field, was a major factor that affected a field's seasonal habitat value for quail. As expected, different aged fields met different habitat needs. Recently established fields (less than 3 years old) provided the bare ground, annual weed, and overstory cover components that characterize quality brood habitat. Conversely, fields three years of age were losing the annual weed and bare ground components that are optimal for quail brood foraging. A similar trend was observed for winter roosting cover. Quail use vegetation 30–90 cm tall in combination with bare ground or light litter at ground level for roosting (Ellis et al. 1969, Rosene 1969, Wiseman and Lewis 1981). In Illinois, Klimstra and Ziccardi (1963) characterized roost sites as being nearly devoid of dead vegetation. By age three, CRP fields began to be too rank at ground level to meet this criterion. We believe the density of ground level vegetation will diminish the value of CRP fields as brood-rearing and roosting cover if succession is not set back.

However, as the CRP fields aged they tended to improve as nesting cover. Intermediate stages of grassland succession (5–10 years) have been suggested to provide optimal nesting cover for bobwhite (Klimstra and Roseberry 1975). Our data suggest that CRP fields in northern Missouri will have little value as nesting cover during the first two years after establishment. During this period, most of the fields we sampled were dominated by annual weeds. Roseberry and Klimstra (1984) reported that areas in annual weeds may provide inferior nesting cover because of the lack of dead grass stems for nest construction. Vegetation height at nest sites in Illinois averaged 49 cm (Klimstra and Roseberry 1975). In addition to vertical structure, Schroeder (1985) suggested that optimal nesting cover should have 50 percent herbaceous canopy cover. The fields we sampled had a mean vegetation height of less than 32 cm by the third growing season and grass canopy cover was 40 percent. Therefore, CRP fields in northern Missouri may just begin to provide quality nesting cover by the third year after establishment. This supports Roseberry and Klimstra's (1984) observation that Soilbank fields in southern Illinois did not receive much nesting use until the fourth year of the program. We believe CRP fields in north Missouri will continue to improve as nesting cover as succession advances.

We detected differences in vegetation structure by conservation practice that may affect habitat suitability for bobwhite. Warm-season grass (CP2) and wildlife habitat (CP4) fields had greater VORs than cool-season (CP1) grass fields. Therefore, CP2 and CP4 fields were more likely to provide concealment for nests than CP1 fields. In addition, CP2 and CP4 fields had taller vegetation than CP1 fields. This suggests that CP2 and CP4 fields will produce nesting cover earlier than CP1 fields. Fields in the wildlife habitat practice (CP4) also had greater forb canopy coverage than the other CPs.

Higher invertebrate densities have been observed in CRP fields established in a grass/legume mixture than in fields established in a pure grass stand (Burger, unpublished data 1989). Nelson et al. (1988) observed higher invertebrate densities in cool season/legume stands than in pure stands of warm-season grass. The higher forb canopy coverage observed in CP4 fields suggests that they may have greater insect abundance and, therefore, provide higher quality brood cover.

Recommendations

The degree of wildlife management occurring on CRP land will be dependent on desires of the landowners, latitude in program guidelines and attitudes of ASCS county committees. Our data suggest that disturbance is a major factor limiting habitat quality on CRP lands during early years of the contract. We recommend that additional emphasis be placed on restricting mowing activities after the establishment year. Although CRP contracts do not require annual mowing, it appears to be a common practice in our study area, at least on a county basis.

We observed that CRP fields rapidly lose the annual weed and bare ground component over time. This suggests that after the second or third year, their value as roosting or brood rearing habitat may diminish. Some type of disturbance that reduces litter and vegetation density at ground level such as fire or disking, may be necessary to maintain the bare ground and annual weed component after the third year. We suggest that such management practices may be most effective if applied to alternate halves or thirds of the field on about a three-year rotation. This would maintain early successional roosting and brood rearing habitat in close juxtaposition to more mature, denser nesting habitat.

We believe that the CRP has tremendous potential to provide essential grassy habitats for quail in intensively farmed areas that may be deficient in these components. We want to emphasize that the CRP will not be uniformly good or bad for quail. The value of these grass fields will depend on the availability of other cover types in the immediate vicinity of the CRP field. Furthermore, the habitat needs that these fields meet will vary with the age of the field. Newly established fields may provide roosting and brood rearing habitat, whereas older, better established fields may provide nesting habitat.

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Special Session 2. *Conservation Education: Making the Investment*

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Status and Trends of Conservation Education Programs

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Introduction

Education is a content and process-oriented learning activity with the goals of influencing knowledge, skills and attitudes and affecting behaviors of learners. Most public and private agencies, organizations and individuals involved with conservation have either passive or active educational activities as part of their objectives. Passive education is provided in the form of information for interested persons to use if it is encountered through news releases, magazines and electronic media. Active education is taken to the learner with goals and objectives for behavioral outcomes using curricula, facilitator training and educational packages. Both processes can be evaluated.

The overriding goal for conservation education is to provide a quality environment and life where environmentally literate citizens are capable of living and making decisions compatible with functions of the world. Philosophies about the role of humans in environmental matters are varied, dynamic and often conflicting. Agencies, organizations and publics have needs, wants and mandates that may conflict, which also confounds the role of an environmental education mission and the ability to evaluate success or failure of programs.

This paper reviews literature and programs that have passive and active components offered in formal and informal settings to promote environmental learning. It is assumed that education should be used as a tool by natural resources professionals as part of the goal for promotion of environmental integrity, wise use and enjoyment. The focus of the review is on wildlife-based programs and practitioners in the public and private sectors. In most cases, partnerships among agencies and organizations exist that integrate educational content, processes and facilitation. The need for evaluation is reviewed.

What State, Federal and National Agencies Are Doing

The U.S. Fish and Wildlife Service is an example of federal natural resource agencies that offer environmental education programs. They reported to us the following information about their programs. Information and education efforts were ranked in order of priority as news releases and displays, radio and television, then natural resources education workshops or activities for teachers. Activities over the last 10 years were increased for rural and urban audiences and were unchanged for adults, youth, men and women. Activities increased for nongame interests and were down for game-oriented activities. They also reported that a major plan to coordinate their environment education efforts is scheduled for implementation by 1991. The top five current education programs of the U.S. Fish and Wildlife Service are listed below.

1. Refuge visitor center displays and audio-visual programs.
2. Hunter education programs through Federal Aid to states.
3. Public affairs activities such as films, news releases, videos, brochures, etc.
4. International activities—assistance to other governments with educational programs.
5. Extension activities with Cooperative Extension and Sea Grant.

In 1986, Adams et al. (1988) conducted a survey of the information and education divisions (I&E) divisions in state natural resource agencies to determine (1) the amount of money and personnel devoted to these divisions, and (2) their areas of program emphasis. Responses from 40 state natural resource agencies revealed that I&E divisions received 2.7 percent of the total reported agency budgets and were staffed by 2.6 percent of the total personnel. The primary program activity of I&E divisions was the production of print media, with emphasis on publication of the agency magazine. I&E personnel ranked the agency magazine, Project WILD, and hunter education as the most important activities. In addition, news release, television programs, and teacher education were rated as important to extremely important. However, the personnel and budgets allotted to these program areas was very low. Adams et al. (1988) concluded that if I&E divisions hope to meet the needs of the growing urban, non-hunting public, they will have to redirect dollars and personnel away from traditional programs that reach a limited clientele to avenues that will reach the public at large. An option not mentioned is to generate funds from non-hunting publics, who receive benefits from wildlife agencies, rather than decreasing attention to hunting publics, whose goals must continue to be met and who generate existing funds.

Research has shown that educational programs have their greatest influence during childhood and that the foundation of environmental attitudes begins during this impressionable time (Hair and Pomerantz 1987 and references cited therein). For this reason a number of state natural resource agencies are devoting a significant part of their formal and informal educational programming to children and young adults. Programs for hunter and aquatic education are examples of educational programming by wildlife agencies that use resource-based activities, hunting and fishing respectively, to introduce basic ecological principles and to enhance user behavior. The paper by Adams and Eudy (1990) in this session advocates an activity-based learning system for agriscience students at the secondary level.

Cooperative Extension has consistently advocated the activity-based approach to education. Shooting sports for 4-H is offered by many states as a method to combine shooting skill training with broader wildlife issues. A new national thrust by Extension offers wildlife habitat judging, where youth integrate animal biology with landscape ecology (rural and urban), and their integrated management. In New York, Cooperative Extension is sharing their expertise in non-formal educational strategies through the Sportfishing/Aquatic Resources Education Program. This new aquatic education program for youth is a joint venture between Cooperative Extension and the New York State Department of Environmental Conservation. Most states are now planning and implementing Extension 4-H natural resources education programs as part of a new initiative that started with a national leader training forum in Colorado during 1988.

A variety of environmental programs in Canada included emphasis upon citizen participation, which is a true form of action-based education. The Canadian Environmental Protection Act of 1988 provided for public inputs in the process of regulating substances and made provisions for citizens to serve on boards and committees. Ontario used over 11,000 volunteers in 1988 for their Community Wildlife Habitat Improvement Program. Wildlife stewardship was also practiced by the Wildlife Habitat Canada Foundation along the Niagara Escarpment, for pothole projects in Saskatchewan, habitat retention in Alberta and on private land on Prince Edward Island. According to their supporters, the great value of these programs lies in the education of people in addition to the habitat work. There is even a Harmony Foundation dedicated to cooperation and education rather than confrontation for solving environmental issues. These initiatives along with education by natural resource agencies, environmental education in schools and nature centers offered by public and private sectors accent strong initiatives to bring publics into enlightenment and action. The paper by Blanchard and Monroe (1990) in this session illustrates further that education is a valuable tool for attaining natural resources management objectives.

Partnerships Among Environmental Educators

Partnerships among the state, provincial and federal natural resource agencies and private organizations devoted to educating young people are being utilized more often. They include joint programming with: (1) state education departments, (2) zoos and museums, (3) other state environmental regulatory and management agencies, (4) universities, (5) private conservation groups and (6) Cooperative Extension, among others. Integration of natural resource education programming within the public school curricula requires the cooperative efforts of the department of natural resources and the state education department. Often the subject matter expertise is found within the management agency, whereas the program delivery depends largely on teachers within the public schools. The Environmental Protection Agency (EPA) has the potential to expand upon these partnerships as a lead agency for environmental education if the new National Environmental Education Act (S.1076) passes. EPA would then establish offices in Washington, D.C. and 10 regional offices. They would coordinate environmental education functions and provide technical assistance to state and local natural resource agencies and education departments.

Several states have integrated or are in the process of integrating natural resource education within the mandated school curriculum. Various approaches are being used. Some states, such as Wisconsin, California and Pennsylvania, have mandated legislatively that environmental education be taught in the public schools. Wisconsin has put some teeth behind this mandate by making the funding of local school districts conditional on the completion of an environmental education action plan. In addition, preservice training in environmental education is required for teacher certification. To meet the needs of current teachers, extensive in-service training programs have been established through the University of Wisconsin-Stevens Point. Other organizations such as the Department of Natural Resources, Cooperative Education Service Agencies, and The Wisconsin Association for Environmental Education are also helping to implement the mandate for district environmental education plans (Cooper et al. 1989).

Other states are trying to effect the implementation of environmental education in the classroom through informal networks. The Pennsylvania Office of Environmental Education was created in 1986 as an outgrowth of the Pennsylvania Environmental Education Masterplan. This office exists through a joint agreement between the secretaries of the Department of Environmental Resources (DER) and the Department of Education and has established numerous partnerships and extensive networking to influence environmental education efforts in the state. Examples of some of these partnerships include: the DER Bureau of Forestry staff with teachers for Project Learning Tree workshops; DER Bureau of State Parks with six Pennsylvania universities and numerous school districts to assist with internships, curricula and course development, teaching, and school site development; and DER with the Philadelphia Zoo to assist the Zoo in environmental education programs and to assist DER in reaching urban populations (Pennsylvania DER Public Liaison Office 1989). The state of Connecticut has an environmental plan that lays out similar networks among the resource management agency, education department, universities, museums, and others with interest and expertise in environmental management and education (Connecticut Department of Environmental Protection 1987).

To facilitate the integration of natural resource education, several states have integrated a natural resource curriculum with the state's mandated public school curricula. The Missouri Conservation Department has done this and designed its educational materials so they not only educate students about conservation issues, but also help teachers implement the curriculum requirements for elementary and secondary programs in the public schools. In addition to providing instructional materials, the Missouri Conservation Department employs 14 regional environmental educators who work with teachers in the schools and train them in the use of materials. Several states, such as Florida and Oregon, have integrated the curriculum framework from Project WILD with their state's mandated education requirements to demonstrate the applicability of these materials in classroom teaching.

New York State has used a similar integrated approach. The Department of Environmental Conservation (DEC) established a set of goals and objectives for natural resource education for elementary students. Recognizing that the wealth of printed materials for environmental education was being largely unused by the majority of New York teachers, the DEC has taken a different approach to in-service training and used videotapes to introduce teachers to environmental education activities. The curriculum framework for this new teacher-training program, the Wildlife Ecology Support Supplement, is correlated with the New York State Elementary Science Syllabus.

Analysis of Natural Resources Education and Materials

A 1987 symposium sponsored by the North American Association for Environmental Education (Disinger 1987) assessed trends and issues in environmental education for school curricula. Papers focused upon the need for "whole earth learning" and whether environmental curricula should be infused or presented as single subjects in overall school programs. In conjunction, the ERIC clearinghouse for science, mathematics and environmental education conducted a survey of state education agencies. Persons responsible for environmental education were asked to provide perceptions about their programs. Survey results were obtained about curricula from approximately 40 states and reported as the symposium (Disinger 1987). Results are summarized here about the extent of environmental education included in the curricula for both elementary and secondary schools in 38 states (Table 1). The majority of environmental subjects (98 percent elementary and 90 percent secondary) were infused into the curriculum. Environmental education was listed by various labels and Table 2 summarized those topics offered from 39 states for elementary and secondary students. Infusion of environmental education topics into curricula has advantages for interdisciplinary education; however, it becomes difficult to assess the true quantity and quality of environmental education programs. Howe et al. (1987) contended that environmental education had not found a discrete place in school curricula and that time spent on environmental education was minimal. Sewing (1986) grouped reasons for the failure to deal adequately with environmental education into four barriers: conceptual, logistical, educational, and attitudinal. Perhaps the question of

Table 1. Survey of the extent that environmental education is included in the curricula of elementary and secondary schools in 38 states of the United States (Disinger 1987).

	Amounts of environmental education in programs				
School level	0–20%	21–40%	41–60%	61–80%	81–100%
Elementary					
Number	6	7	3	5	17
Percentage	16	18	8	13	45
Secondary					
Number	8	10	2	6	12
Percentage	21	26	5	16	32

Table 2. Common forms of elementary and secondary programs taught in 39 states of the United States (Disinger 1987).

	Topic titles						
School level	Nature study	Outdoor education	Conservation education	Population education	Energy education	Marine education	Science, society technology, environment
Elementary							
Number	33	26	26	7	27	16	8
Percentage	85	67	67	18	69	41	21
Secondary							
Number	15	17	21	17	31	20	31
Percentage	38	44	54	44	80	51	80

whether environmental education is discrete or diffused within the curricula should not be the central issue. Rather, it should be instructive to learn about the quantity and quality of topics covered and materials used for instruction.

An extensive review and analysis of natural resource education materials was performed in conjunction with the development of New York State's Wildlife Ecology Support Supplement (Pomerantz 1990). A bibliography and library of natural resource education materials appropriate for upper elementary students was compiled that included publications from state natural resource agencies (e.g., Alaska, New Jersey, Missouri), federal natural resource agencies (e.g., U.S. Fish and Wildlife Service and U.S. Forest Service, conservation organizations (e.g., National Wildlife Federation's NatureScope, New York Zoological Society's WIZE and ZIPS, Western Regional Environmental Education Council's Project WILD, Aquatic Project WILD and Western Regional Environmental Education Council and American Forest Foundation's Project Learning Tree), educational institutions (e.g., ERIC materials, OBIS), and independent authors.

One hundred and nine sources were initially reviewed to determine whether their general content and instructional levels were appropriate for the Wildlife Ecology Support Supplement goals and objectives at the elementary level. Analysis was made of 72 instructional guides designed for grades 3 through middle school that dealt with natural resource issues and general ecological principles. The individual lesson plans within each activity guide were then screened to determine the specific curriculum objectives they addressed and how well each lesson met certain instructional criteria. A highly modified version of Gardella's screening instrument was used. (*See* Pomerantz 1990, for details of the screening procedure.)

The screening of approximately 1,000 individual lessons demonstrated the relative emphasis being placed on content areas and instructional goals in these educational materials. The area that received the most extensive coverage was basic ecological principles. The lessons emphasized the interdependence of all living things, indicated that people are an interactive part of the environment and that people can analyze the impact of their actions. Between 30 and 40 percent of the lessons covered these topics extensively and another 30 percent gave some coverage. The cultural, economic and ecological importance of wildlife and the necessity of responsible stewardship was covered extensively in about 5 to 9 percent of the lessons and given some coverage by 21 to 27 percent. Identification of resource management activities was given some coverage in about 23 percent of the lessons and extensive coverage by 6 percent or less. Specific treatment of management issues and decisions was given some coverage in approximately 15 percent of the units, with extensive coverage in 6 percent or less.

Analysis of instructional goals of the lessons showed that 98 percent contributed to knowledge about wildlife and the environment, compared with 31 percent that dealt with knowledge about wildlife and environmental management principles and practices. Forty-two percent of the units dealt with attitudes of responsibility or stewardship for wildlife and the environment. The instructional goals dealt with least often were skills to evaluate and apply information about wildlife and environmental management principles and practices (14 percent of the units) and behavior that exercises responsible stewardship (11 percent of the units).

Adding Action to Natural Resources Programming

From the analysis of natural resource education materials for elementary students, it can be seen that the greatest emphasis is being placed on basic knowledge of ecological principles. This is an appropriate emphasis at the lower grade levels where children need to be introduced to the ecological foundations that underlie resource management. However, if resource managers expect children to be able to understand resource management issues and begin to apply their knowledge of ecological principles to resource management problems, they must begin to expose students to these issues. Furthermore, students need to be given opportunities to develop the critical thinking skills and behavior that will enable them to go beyond awareness and knowledge to environmental action. As Volk, et al. (1984) indicated, the end goal of environmental education is action, but very few curricula incorporate these goals into their program. The analysis of natural resource education materials available to teachers confirms this observation. (Pomerantz 1990). Iozzi (1989a) suggested that science tells what can be done and society must determine what should be done. Holistic learning in both cognitive and affective domains are best (Iozzi 1989b). Jordan et al. (1986) evaluated behavior of high school students who were taught at residential environmental workshops with two different strategies. Students who were taught in both awareness of environmental issues and action strategies demonstrated increased levels of knowledge about environmental action and they participated in a greater number of environmental behaviors than students who received awareness training only. The presentation in this session by Bill Hammond provides further guidance for action programming.

Whose Affective Domain

There are questions within the cognitive and affective domains of education about the type of information to teach based upon one's attitudes about life and death, use and non-use, game and nongame, manipulation and preservation, consumption and nonconsumption. Other labels in vogue that repeat older paradigms or perhaps offer new approaches to thought include: holism versus concern about specific animals and environments, conservation biology and landscape ecology versus wildlife and habitat ecology, and integrated thought and action versus specialization. Perhaps the points are moot if the actual goals are and were to provide for healthy animal populations in healthy environments for intrinsic and extrinsic values. However there is no doubt that persons interested in wildlife and landscapes have disparate philosophies as they view the earth. Some persons want to save everything while others are utilitarians. People trap or wear furs and protesters march in defiance. Biology students want more hands-on experience with management and manipulation techniques, yet some see no reason for human intervention.

Teacher cognitions of wildlife management concepts were reviewed by Hooper (1988) in California. He found that California teachers had basic knowledge about habitat needs of wildlife, but they had misconceptions about the role of wildlife management tools such as hunting, stocking and introductions of exotic species. If facts are not understood about various activities, concepts or issues, then one's approach to cognitive and affective education would likely reflect instruction bias.

The reality of environmental enhancement and therefore education from a pragmatic perspective must contain all of the labels and philosophies just presented. Aside from hands-off attitudes and strict preservation, environmental management and environmental education needs to include various needs, uses and attitudes. For example, landscape ecology as a holistic paradigm requires understanding of the parts and perhaps manipulation of the whole or combinations of the parts. Conservation biology as a way of thinking needs to include knowledge of individuals, populations and interactions within and among individuals, species and their environments along with the positive and negative impacts extant by humans.

Solutions to the dilemma of what and how to manage or teach requires empathy for dynamic human dimensions in consort with the dynamics of animals and environments. Managers and educators should constantly learn from their publics, and there is a constant need to provide sound cognitive and affective guidance through various forms of environmental education.

Conclusions

The good news is that educators are willing to learn and want to be better teachers. Hooper's (1988) survey of teachers in California indicated that 85 percent expressed interest to attend training sessions. Practicing environmental educators have also found that teachers thirst for help and, fortunately, teachers say they benefit from learning experiences (Simmons 1988). Therefore, environmental and wildlife agencies and environmental educators can know that their educational efforts are not lost. Teaching and curricula development cannot stop with the implementation phase however. It is equally important to know how information is comprehended and used. Stout and Peyton (1988) suggested that curricula may contain problems or create misunderstandings that are not anticipated by curricula developers and consulting experts. Their paper recommended evaluation at the formative and summative phases and offered suggestions for formative evaluations. The paper by Race et al. (1990) in this session provides an evaluation of Project WILD and reveals problems encountered during the evaluation phase.

Environmental professions and educators need to increase their diligence to reach teachers and students with thoughtful and effective teaching content, materials and attitudes. Adams and Thomas (1986) recommended preservice teacher education and implementation of "conservation education" positions in schools and universities offering wildlife-related curricula. A challenge to the field of natural resource education is to bring children and adults, teachers and learners, beyond the awareness of resource management concerns to an informed, participatory level. The extent to which the entire resource management community can facilitate this through its educational programming and evaluation will be reflected by the success of management programs.

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Trends and Opportunities in Natural Resource Education

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Introduction

The natural resource orientations and concerns about the environment by United States residents are undergoing fundamental changes that may affect the course of natural resource education in the future. The natural resource orientations of U.S. residents show a clear pattern of increased interest in appreciative rather than harvest activities (U.S. Department of the Interior 1988). There is a high and increasing level of public concern about environmental pollution and natural resource management (Harris 1985). There is little formal inclusion of natural resource-related curricula in public schools (National Research Council 1988). It is important to examine the education opportunities that have evolved with these changes in relation to the educational programs available or possible within the natural resource profession.

Trends in Natural Resource Education Within the Profession

The program diversity that exists within selected natural resource groups was examined in terms of (1) a review of the wildlife and fisheries journals, (2) public education programming within information and education (I & E) divisions within departments of natural resources, and (3) comparative credit hours in wildlife, fisheries, natural resource, urban, and teacher education offered in colleges and universities.

The journals. Adams et al. (1988) reviewed nearly 6,000 articles in seven wildlife and/or fisheries management journals to determine the importance given to education in the management process. They found only 113 education-related articles of which none were found in *The Journal of Wildlife Management, The North American Journal of Fisheries Management,* or *Transactions of the American Fisheries Society.* This study further revealed that the token attention given to education as part of the management paradigm focused heavily on professional rather than public concerns.

I&E programs. Adams et al. (1988) conducted a national assessment of the programmatic emphases of I&E divisions. They found that the primary method of public education was the print media, including the agency magazine, news releases, and other publications. Over half of I&E program budgets were dedicated to these publications, compared to 3 percent for Project WILD, 6 percent for television productions, and 5 percent for teacher education. Furthermore, Thomas et al. (1988) found that for every $1.00 dedicated to teacher education and Project WILD combined, $3.00 were allocated to hunter education by I&E divisions.

Credit hours. Using the 1989–90 catalogues, we counted the total number of credit hours in wildlife, fisheries, urban wildlife/fisheries and teacher training courses offered by "schools" (N = 86) of wildlife and/or fisheries sciences in the United States. This analysis (Figure 1) revealed that the formal institutions for natural resource education focus primarily on professional (e.g., wildlife and/or fisheries management) rather than public (e.g., urban studies or teacher education) training needs. We found that the average number of credit hours in wildlife, fisheries, natural resources, teacher education, and urban studies were 16, 9, 4, 0.7, and 0.2, respectively. Our results on urban studies agreed with the findings of Adams et al. (1987) that few courses dealing specifically with urban wildlife were being offered by North American colleges and universities.

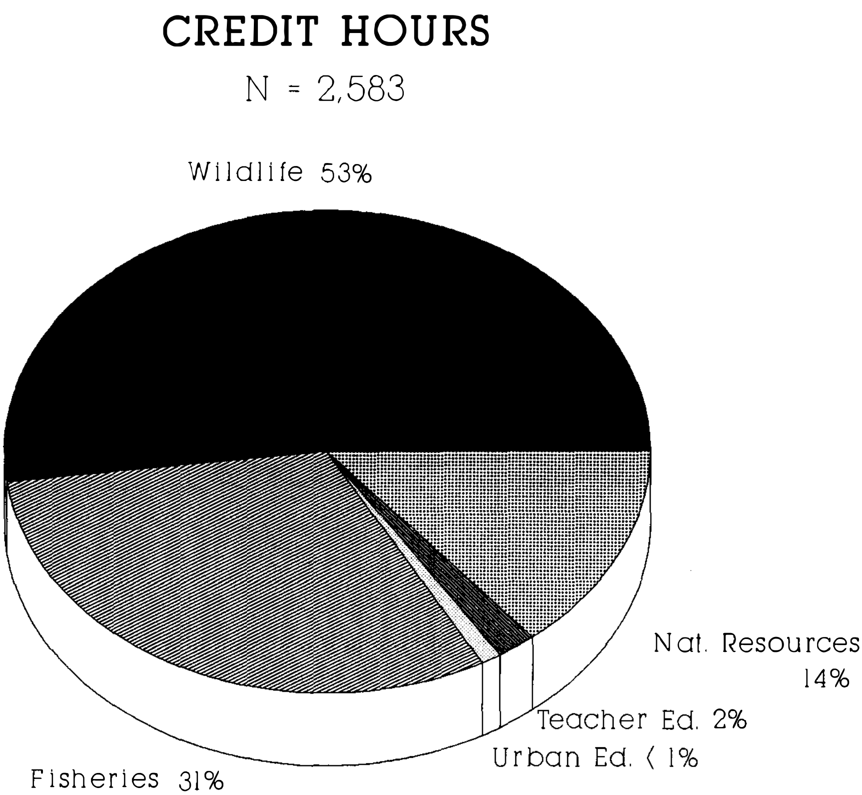

Figure 1. Percentage of credit hours dedicated to wildlife, fisheries, natural resource, teacher education, and urban-related courses in "schools" of wildlife and/or fisheries sciences in America.

Education Opportunities

Nonformal education. Nonformal education can be defined as a method of information transfer that can occur in any setting to individuals for whom participation is a personal choice. Participant expectations can be personal intrinsic rewards, development of skills, knowledge enhancement, or recreation. The "teacher" is a person, technology or media that provides information.

Within the natural resource profession, nonformal public education is a high priority within the National Wildlife Federation, National Audubon Society, Natural Science for Youth Foundation, Cooperative Extension Service, National Institute for Urban Wildlife, Aquatic Resources Education Council, Western Regional Environmental Education Council and I&E divisions of state departments of natural resources, among others. However, all have targeted—and often—the same audiences. The basic problem with nonformal education is that often the result is "preaching to the congregation." People who are inherently interested in natural resource issues will purchase the memberships or magazine subscriptions, attend the workshops, or view the television programs of the above agencies. Perhaps this condition is an inevitable blessing and curse of nonformal education groups. However, an emerging opportunity for these groups is the inclusion of the wealth of educational material they produce into formal education. We discuss this opportunity below.

Formal education. Formal education can be defined as the process of transferring information in public or private schools (K–Ph.D) to individuals for whom participation leads to the completion of a specified set of educational requirements. Participant expectations include academic credits or degrees. Teachers are individuals whose primary professional activity is being an educator.

The natural resource profession has an opportunity to participate directly in public school education. Agriscience teachers in hgh schools across the United States are examining alternative curricula that make their programs more relevant to students. These programs are being restructured in terms of subject matter focus, quality of instruction, expanding student clientele, societal relevancy and with particular emphases on resource ecology issues (National Research Council 1988). This trend was examined in a 1989 statewide assessment of natural resource education conducted by 1,400 Texas agriscience teachers. This assessment revealed that high student demand has preceded full curriculum development and teacher preparedness in resource ecology. Herein lies the opportunity for nonformal and formal educational programs to become integrated directly into public school education.

Assessment of the Texas Agriscience Curriculum

Methods

A one-page survey was sent to all (N = 1,400) Texas agriscience teachers. This survey was used to determine: (1) the extent of resource ecology education in agriscience classes now and in the future, (2) the types of resource ecology issues taught, (3) teaching aid needs, and (4) present science backgrounds of agriscience teachers.

The assessment was explained and supported in a cover letter by Jay L. Eudy, Director Agricultural Science and Technology, Texas Education Agency.

Results

The response rate to the survey was 39 percent (N = 539). Survey results are generalizable to the population of agriscience teachers given a sampling error of +/−3 percent.

Most (82 percent, N = 443) of the agriscience teachers were teaching resource ecology courses at the 10th (86 percent), 11th and 12th (93 percent) grade levels. The reported student enrollment by 413 teachers was 11,694 (Mean = 28/year, Range = 5 to 150/year). Of the 18 percent (N = 96) who were not teaching a resource ecology course in 1988–89, 54 percent anticipated teaching one within the next two years.

The average number of years of teaching experience reported by respondents was 14 (range = 1 to 43). However, a comparison of the frequency of inclusion of selected resource ecology issues with the past academic training of Texas agriscience teachers revealed a need to improve their subject matter understanding and pedagogical practices. For example, the resources ecology curriculum of 435 agriscience teachers included wildlife management (91 percent), conservation (79 percent), outdoor recreation (71 percent), natural resources (68 percent), careers in natural resource management (57 percent), ecology (52 percent), fisheries management (50 percent), and environmental sciences (49 percent). Comparatively, the average semester hours of past academic training in wildlife management, environmental sciences, ecology, and fisheries management were less than or equal to 1 semester hour (Table 1). This low level of academic training in these fields would also affect agriscience teachers' understanding of natural resource conservation and management, and career opportunities in resource ecology.

Agriscience teachers interest in the nine teaching aids proposed in the survey showed a clear pattern of need for classroom materials (Table 2). This need suggested that agriscience teachers are generally unaware of how to secure better materials or receive help in the use of available instructional materials. A moderate interest level in a two-week short course indicated that time may be a limiting resource, i.e., time to learn and prepare to teach a new subject area. Overall, these findings indicate

Table 1. The average number of semester hours in eight science-related subject matter areas as reported by 495 Texas agriscience teachers.

Subject	Semester hours
Animal science	24.0
Biology	12.2
Chemistry	9.4
Earth science	3.4
Wildlife science	1.4
Environmental science	0.9
Ecology	0.8
Fisheries science	0.1

Table 2. Summary of the average interest (5 = high, 1 = low) of 495 Texas agriscience teachers in nine resource ecology teaching aids.

Teaching aid	Interest level
Audiovisual aids	4.6
IMS student materials	4.6
Lab activities	4.6
Curriculum guides	4.3
State agency materials	4.1
Two-week short course	3.9
Textbook	3.6
State agency consultants	3.5
Graduate courses	2.7

several factors to be considered in establishing a short-course which would strengthen the content backgrounds (*see* Table 1) of agriscience teachers.

A Plan for Action

How can the natural resource professions respond to this invitation to implement natural resource education directly into public school curricula? The development of a formal educational program in resource ecology requires that three conditions be satisfied. First, there must be a state-mandated curriculum that provides an entry point. In texas and Missouri, this entry point has been provided through agriscience education. Other states may want to explore this option.

Second, a protocol for pre- and inservice teacher training will need to be established. Schools that train natural resource professionals (e.g., wildlife, fisheries, forestry) may want to explore two options in order to satisfy the second condition. They may develop a teacher training program that focuses on natural resource issues within their own department or as an alternative in the Department of Agricultural Education. We suggest the latter option because many of the criteria required to offer an accredited teacher training program and a potential student clientele are already available.

Third, a high-school-level curriculum in resource ecology needs to be developed. This curriculum could be called Project NATURE: Needed Activities to Understand Resource Ecology. The goal of Project NATURE would be to improve the science backgrounds of teachers (e.g., agriscience, biology, extension) by enhancing their present knowledge, confidence, and classroom practices in resource ecology. Project NATURE needs to be an activity-based learning system built around a conceptual framework that includes principles of ecology, management and conservation; techniques; and human dimensions in resource ecology.

Project NATURE activities (Table 3) may need to be built from scratch or represent modifications of those already produced by some of the nonformal educational groups listed above. Activities could be field or laboratory investigations, field trips, or viewing of audiovisual productions. The tentative activity list provided in Table 3 is not exhaustive and does not include a list of multiple activities that could be included under one heading. The information in Table 3 demonstrates how much

Table 3. Tentative activity titles for a resource ecology curriculum.

I. Terrestrial ecosytem activities
   A. Identifying common mammals, birds, and reptiles in my community.
   B. Comparing soil, grassland, forest, desert and urban ecosystems.
   C. Identifying wildlife in my backyard.
   D. Examining the life histories of a white tailed deer, quail, and snake.
II. Aquatic Ecosystem activities
   A. Identifying common amphibians and fish in my community.
   B. Comparing pond, stream, and marine ecosystems.
   C. Examining the life histories of a frog and salmon.
III. Ecosystem analysis
   A. Measuring species diversity in plant and animal communities.
   B. Using radio and satellite telemetry.
   C. Understanding food chains and food webs.
   D. Methods of aging an animal without knowing its birthday.
   E. Comparing renewable and nonrenewable resources.
   F. What is the greenhouse effect?
   G. Making a habitat resource map.
   H. Establishing a field study area at school.
   I. Estimating population numbers.
   J. Measuring an animal's home range.
   L. What is acid rain?
   M. Understanding the water cycle.
   N. Measuring air pollution.
   O. Understanding water pollution due to sewage.
   P. Understanding future energy needs and alternatives.
   Q. Understanding impacts of exotic animal or plant introductions.
IV. Ecosystem management activities
   A. Applying the principles and techniques of:
      1. wildlife management.
      2. fisheries management.
      3. aquaculture.
      4. wildlife rehabilitation.
      5. habitat reclamation.
      6. energy conservation.
      7. water conservation.
      8. conservation of renewable and nonrenewable resources.
      9. wildlife damage control.
   B. Measuring people's natural resource attitudes, activities, and expectations.
   C. Developing in-school exhibits on resource ecology issues.
V. Public policy activities
   A. Identifying natural resource laws and regulatory agencies.
   B. Identifying historical turning points in resource management.
   C. Determining the economic importance of wildlife and plants.
   D. Identifying careers in resource ecology.
   E. Assessing uses and abuses of natural resources in my community.
   F. Examining the relation between human population growth and losses of natural resources.
   G. Determining whether urban environments are sustainable ecosystems.

the natural resource profession can offer in the development of a high-school-level resource ecology curriculum and in pre- and inservice teacher training.

Educational Significance of Project Nature

It is indeed remarkable that a compendium of activities such as those proposed is not already available. Project NATURE will provide the first organized set of activities for the presentation of resource ecology at the high school level. This type of curriculum has the support of the Texas public (Adams and Thomas 1989), agriscience teachers (Table 2) and the state education agency. It is structured around the disciplinary expertise of natural resource professionals and agency networks. Project NATURE supplements the science background of agriscience teachers (Table 1), meets their expressed needs (Table 2) and provides a teaching tool that will promote substantive and measurable growth in student knowledge and teacher effectiveness in resource ecology education. A significant multiplier effect is possible through curriculum implementation in other states, curricula and academic levels.

Finally, Project NATURE provides a mechanism to extend the outreach mission of nonformal and formal educational groups. Many of the activities proposed in Table 3 already have been developed by these groups and, through some modifications, can become directly incorporated into the curriculum. For example, the National Audubon Society and the Cooperative Extension Service have produced many excellent films that could be incorporated. They also have produced an outstanding array of field and laboratory activities relevant to the conceptual framework of Project NATURE. The vast array of laboratory activities in "schools" of wildlife and/or fisheries management could also be sources of information for curriculum development (e.g., radiotelemetry, transect analysis, and aging techniques among others). The biggest problem will be to limit the number of excellent contributions that nonformal and formal natural resource educational groups can offer in the development of the Project NATURE curriculum.

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A Statewide Evaluation of Project WILD's Effect on Student Knowledge and Attitude Toward Wildlife

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Introduction

Project WILD is an interdisciplinary, supplementary environmental education program with an emphasis on wildlife. Developed in 1983 as a joint project of the Western Regional Environmental Education Council (WREEC) and the Western Association of Fish and Wildlife Agencies (WAFWA), Project WILD's primary audience is teachers of kindergarten through high school students. Project WILD activities are designed to be integrated into existing language arts, science, social studies or mathematics curricula.

Since the development of Project WILD, a number of studies have been conducted, assessing its educational quality and effect on teachers and students. Five studies have researched teacher use of Project WILD materials (Charles 1986, Cantrell 1986, 1987, Zosel 1988, Smith-Walters 1988). However, only two studies have been conducted to measure how Project WILD affects student learning (Fleming 1983, 1985). Fleming (1983) conducted a formative evaluation of the Project WILD curricula using a field test to measure and interpret Project WILD's effect on students and teachers. Project WILD was found to be effective with kindergarten through high school students. Teacher interest and background knowledge about wildlife had significant effects on student learning and attitudes, while student success was not dependent on residence in urban, suburban or rural areas.

A study in Lee County, Florida, on the effects of Project WILD on kindergarten through fifth grade students also measured student learning and attitudes toward wildlife (Fleming 1985). Students exposed to Project WILD showed statistically significant improvements on both the cognitive and affective instruments compared to the control group (students not exposed to Project WILD activities).

The primary purpose of our study was to assess Project WILD's effect on student knowledge and attitudes toward wildlife in Colorado and to assess if the program affects children in rural and urban communities equally.

Methods

School districts throughout Colorado were categorized according to whether or not they integrate Project WILD into their curricula. School districts were further subdivided according to the size of the community in which they were located and whether the community was in an urban/suburban or rural area. Within a chosen district, one or two schools (depending on the size of the district) were randomly selected to participate. Two life science classes from each school participated in the evaluation. Entire classes were used because teachers administer Project WILD activities to all students in a given classroom, hence comparisons of classrooms, not individual students, was appropriate. A total of 680 students from 26 classrooms participated in the study.

Because many school districts in Colorado are changing from a junior high school system (seventh, eighth, and ninth grade) to a middle school system (sixth, seventh, and eighth grade), the youngest students in either system were used throughout the study. Sixth and seventh grade students (11 and 12 years old) were chosen because they are less likely to have formed definitive attitudes about wildlife, but are likely to do so within a few years (Horvat 1974, Miller 1975, LaHart 1978).

A questionnaire was designed, based on Project WILD materials, to evaluate Project WILD's influence on children's knowledge and attitudes toward wildlife and the environment. A five-category Likert scale was used for all questions so that students would not feel they were being tested, even on knowledge questions. To assess the possible effect of other wildlife-related influences on student knowledge and attitude, 10 demographic questions were included at the end of the questionnaire. Demographic questions asked for information about age; gender; degree of participation in outdoor activities such as hunting, fishing, camping and hiking; and exposure to wildlife-related books and television. Questionnaires were administered to participating classrooms between 13 March and 11 May 1989. Participating teachers completed a brief teacher survey designed to assess (1) the number of Project WILD activities used per school year and (2) the extent to which other types of environmental education curricula are used (in addition to Project WILD) in the classroom. (Details regarding questionnaire development are provided in Race [1990].)

Answer sheets were read by computer. A knowledge score was calculated by first scoring a student's response to each knowledge question. On knowledge questions, the two correct answers (either strongly agree/agree or strongly disagree/disagree, depending on how the question was phrased) were scored as 1 point, and all other responses were given 0 points. Points were then summed to arrive at a cumulative knowledge score for each student. Attitude questions were scored on a scale from 1 to 5. Higher attitude scores indicated attitudes that were more consistent with Project WILD. A cumulative attitude score was calculated for each student by summing responses to all attitude questions. Knowledge questions and attitude questions were analyzed separately. Mean knowledge and mean attitude scores were calculated for each class.

Results and Discussion

Two-way analysis of variance showed no significant differences in student knowledge or attitude between students who have been exposed to Project WILD and students who have not participated in Project WILD activities (knowledge $p = 0.32$, attitude $p = 0.60$). This finding conflicts with evidence from Fleming (1983, 1985) who found that students exposed to Project WILD showed significant improvements on both knowledge and attitude instruments compared to controls (students not exposed to WILD).

Our results, however, were confounded by inconsistencies within the control groups. We discovered on reading the teacher surveys that, although none of the control teachers used Project WILD, several taught other environmental education curricula, such as "Class Project" (National Wildlife Federation) and "Living Lightly in the City" (National Audubon Society). These curricula use basically the same format and present similar information as Project WILD. These teachers were classified as "controls" in this study because they did not specifically use Project WILD materials. However, their students were still exposed to some of the same types of environmental education activities as the Project WILD group, but from different sources. Thus, while attempting to measure only Project WILD's effect, we were comparing students exposed to Project WILD to students exposed to other environmental education curricula.

We attempted to compare classes of teachers that used any type of environmental education curricula (Project WILD, Class Project, Living Lightly in the City) with classes of teachers that used none at all. The purpose behind this comparison was to determine if students exposed to *any* environmental education curricula performed differently on the questionnaire than students not exposed to any type of environmental education. The comparison was not possible because of the insufficient sample size of the new "control group." Twenty-three of the 26 participating classes had been exposed to some type of environmental education curricula. Environmental education curricula have become so pervasive that evaluating the long-term effect of any one program has become increasingly difficult.

Urban/Rural Differences

Two way analysis of variance showed a significant difference between urban and rural students' responses (knowledge $p = 0.008$, attitude $p = 0.03$). Urban students scored higher than rural students on both the knowledge and attitude portions of the questionnaire. These findings also conflict with Fleming (1983), who concluded that Project WILD's effectiveness was not dependent on residence in urban, suburban or rural areas.

Kellert and Westervelt (1983) found significant differences in knowledge and attitude about animals between rural and urban children. Their results suggested second grade rural children were more interested in and knowledgeable about animals than children in other residential areas, particularly large cities. However, by eighth grade the trend started to change, and by eleventh grade the highest knowledge scores were found among suburban students. Because sixth and seventh grade students were tested in our evaluation, the differences found in wildlife knowledge between urban and rural students might be a function of the general trend of increasing wildlife knowledge among older suburban students observed by Kellert and Westervelt (1983).

Differences between urban and rural students' knowledge and attitude scores may also be attributed to the fact that teachers in urban areas used more Project WILD exercises. Teacher information surveys showed that urban teachers used an average of five Project WILD exercises a year, while rural teachers used an average of two Project WILD exercises a year. Discussions with teachers indicated that there is currently a strong emphasis on incorporating environmental education into urban/suburban classrooms. Urban teachers may use more Project WILD activities because many of the activities can be done in a classroom or urban schoolyard. Many teachers are allowed only one field trip per year, which makes classroom or schoolyard activities a necessity. Project WILD may be more effective with urban/suburban students simply because it is used more frequently than in rural areas.

Male/Female Differences

A pooled t-test comparing male and female responses showed a significant difference on both the knowledge ($p = 0.04$) and attitude scores ($p = 0.004$). Boys scored higher than girls on the knowledge questions, while girls outscored boys on the attitude questions. Our finding agrees with Kellert and Westervelt (1983) and Westervelt and Llewellyn (1985) that males are more knowledgeable about wildlife than females are. Attitudinal differences between females and males are supported by other studies that have been shown young females to be more concerned with animal and environmental problems than young males (Sanders 1974, Pomerantz 1977, Kellert and Westervelt 1983, Westervelt and Llewellyn 1985, Wong 1985). These findings demonstrate the important role gender plays in development of wildlife knowledge and attitudes. The evidence suggests that a fundamental difference exists between how males and females learn about and feel toward wildlife and the environment.

Effect of Other Wildlife-related Activities

Participation in wildlife-related activities outside the classroom was found to influence significantly student wildlife knowledge and attitude. Comparing responses of students who hunt with those who do not hunt showed no significant difference in knowledge scores ($p = 0.10$), but did reveal a difference between the groups in attitude score ($p = 0.000$). Nonhunters had significantly higher attitude scores than hunters.

While 51 percent of all students reported having a family member who hunts, only 30 percent of the students reported that they themselves hunt. Substantially more males (47 percent) than females (14 percent) hunt, and more rural students (42 percent) than urban students (24 percent) reported that they hunt. Although there were no significant differences between hunters and nonhunters on knowledge score, a probability value of 0.10 suggests that a loose association may exist between participation in hunting and wildlife knowledge.

The higher attitude scores among nonhunters reflects a more utilitarian attitude toward wildlife among hunters than among nonhunters. Differences among hunters and nonhunters may also be a reflection of the previously discussed attitude differences between urban and rural students. Almost twice as many rural students hunt compared to urban students. Rural students scored lower on the affective portion of the questionnaire than urban students. Perhaps hunters' lower attitude scores are related to the lower scores of rural students.

Anglers' responses were not significantly different than nonanglers on either knowledge ($p = 0.24$) or attitude ($p = 0.20$) questions. Participation in fishing was widespread, with 69 percent of students reporting that they fished. Differences between males and females were less extreme than with hunting, with 81 percent of males and 60 percent of females indicating participation in fishing. Additionally, 67 percent of urban students and 73 percent of rural students indicated that they fished. Fishing has been shown to be a popular activity with students in sixth and seventh grade (Pomerantz 1977, LaHart 1978, Kellert and Westevelt 1983). Perhaps the popularity of fishing as a sport precludes any differences in wildlife knowledge or attitude between anglers and nonanglers.

A host of other wildlife-related activities showed significant effects on wildlife knowledge and attitude (Table 1). Our findings support previous evidence that television and nature magazines can significantly affect children's wildlife knowledge and attitudes (Pomerantz, 1977, 1984, 1985, Kellert and Berry 1980, Kellert and Westervelt 1983).

Other studies have also found that participation in wildlife-related activities outside the classroom can influence wildlife knowledge and attitudes as much as knowledge learned more traditionally in the classroom (Pomerantz 1977, 1984, 1985, LaHart 1978, Kellert and Berry 1980, Kellert and Westervelt 1983, Westervelt and Llewellyn 1985). Hair and Pomerantz (1987) emphasized the importance of experiential education as an integral part of any wildlife education program.

Conclusion

Because of complications in our study, we cannot conclude whether Project WILD has or has not had an affect on student knowledge and attitude toward wildlife. The pervasiveness of environmental education curricula in the participating classrooms confounded our evaluation of the effect of Project WILD. However, we did find a possible correlation between participation in wildlife-related activities outside the classroom and wildlife knowledge and attitude. Due to the preliminary nature of our study, we cannot make any definitive conclusions on the role that these other activities play.

Table 1. Comparison of mean knowledge and attitude scores based on other wildlife-related activities.

Activity		Mean knowledge score	Mean attitude score
I read books/magazines about wildlife	Never	8.17	46.10
	Sometimes	8.87	51.43
	Often	9.20	54.43
	p	0.01	0.000
I watch T.V. shows about wildlife	Never	8.30	46.66
	Sometimes	8.86	50.94
	Often	9.04	53.56
	p	0.20	0.000
I go camping	Never	8.80	50.55
	Sometimes	8.81	51.07
	Often	8.89	51.66
	p	0.96	0.52
I go hiking	Never	8.43	49.31
	Sometimes	8.95	51.31
	Often	9.01	52.72
	p	0.06	0.000

Wildlife-related activities outside the classroom appear to have a strong influence on students' wildlife knowledge and attitudes because students spend more time engaged in these activities, especially watching television, than in activities at school. Curricula like Project WILD may have a positive effect on student knowledge and attitudes, but wildlife information gained in the classroom is a relatively small influence compared to the influence of other activities that are part of a child's wildlife education. Activities such as watching nature television and reading nature books and magazines as well as hunting and hiking may play a more important role in the long-term development of a child's knowledge and attitude about the environment than exposure to environmental education curricula such as Project WILD. However, Project WILD has an important role in reinforcing positive attitudes toward the environment and providing an opportunity to synthesize, under a teacher's guidance, wildlife information gained from sources outside the classroom.

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Effective Educational Strategies for Reversing Population Declines in Seabirds

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Introduction

In his book, *Game Management*, Aldo Leopold separated the control of hunting as a management tool into three techniques: restrictions through police power, incentives based on self interest, and personal ethics. He claimed that the North American style of game management was overdeveloped with respect to restrictive controls (Leopold 1933).

On the remote North Shore of the Gulf of St. Lawrence, Harrison F. Lewis, Leopold's contemporary and first Head Federal Migratory Bird Officer for Ontario and Quebec, combined all three techniques for restricting the illegal harvest of seabirds and eggs by residents. As incentives he promoted the collection and sale of eiderdown to supplement local income, and he issued permits for collecting gull eggs as a food provision (Lewis 1974). Lewis and his predecessor, Charles W. Townsend, understood local ethics, and that laws unsympathetic with them would not be kept (Townsend 1916).

Today it is generally accepted that the control of the hunting factor is more than a matter of signs and fines. But changing the public's behavior toward wildlife through education is a monumental task. The irony is that sociologists and psychologists question whether durable behavior change reliably follows from providing information alone and can show few documented cases where this has occurred (Festinger 1964, Geller et al. 1982, Caduto 1985, Katzev and Johnson 1987). The provision of information may be a necessary but not a sufficient condition for behavior change.

The 12-year running Marine Bird Conservation Project by the Quebec-Labrador Foundation (QLF) on Quebec's Lower North Shore (North Shore of the Gulf of St. Lawrence) has been addressing the problem of illegal harvest of seabirds and eggs, and through its work with residents is demonstrating a case for educational strategies that can lead to behavior change. Populations of nesting seabirds that declined between 1955 and 1978 have since increased. Probable explanations for the change are improved local enforcement and education, plus an increased availability of prey fish for seabirds (Chapdelaine and Brousseau in press).

The contribution and efficacy of QLF's project in changing local knowledge, attitudes and hunting behavior are reported in this paper. Also discussed are the educational strategies that complemented police power restriction of hunting. The project gives further credence to the value of human dimensions information in the design and development of wildlife information and education programs. It suggests the importance of analyzing social patterns as an outgrowth of geography, culture and economic conditions. It emphasizes strategies for long-term, rather than ''quick-fix'' change.

The Problem Defined

Populations of seabirds nesting in sanctuaries along the North Shore of the Gulf of St. Lawrence experienced dramatic declines during the period 1955–1978, including an 84 percent decline among razorbill (*Alca torda*) and 76 percent decline for Atlantic puffin (*Fratercula arctica*) (Chapdelaine 1980, Blanchard 1987). Decreases also occurred among common eider (*Somateria mollissima*), common murre (*Uria aalge*) and black guillemot (*Cepphus grylle*) (Chapdelaine 1980, Chapdelaine et al. 1986). Reasons for the declines centered around an illegal harvest of birds and eggs by residents and deteriorating conditions in the sanctuaries, as reviewed by Blanchard (1984, 1987).

A face-to-face survey survey of 140 Lower North Shore heads-of-households conducted in 1981–1982 found abundant lack of local knowledge regarding wildlife laws and regulations, a universal utilitarian perspective on wildlife, and high incidence of nongame and out-of-season hunting. The harvest in 1981–82 included eggs, young or adults of all nesting alcids and larids. Results showed that 95 percent of heads-of-households considered it acceptable to harvest seabirds for food, and that approximately 70 percent participated in illegal harvest. Antecedent to the harvest was semi-subsistence lifestyle in which seabirds and their eggs comprised an important food source for residents (Blanchard 1984).

Using Lewis' four pillars of wildlife management—research, enforcement, habitat protection, and education (Lewis 1974)—a review of the federal government's management policy since 1925 for the 10 sanctuaries of the Quebec North Shore showed no educational programs during the period 1955–1978 and a general decrease in habitat protection and enforcement. During that period, the sanctuary caretaker system was abolished and the number of migratory bird wardens severely reduced (Blanchard 1987).

Obstacles to better control of the hunting factor included aspects of geography, local tradition and group norms, lack of local incentives, and the changing economy. The Lower North Shore comprises 400 kilometers of coast, where no road links all 15 villages to the outside world. Seasonal subsistence activities—wood gathering, berry picking, bird harvesting—supplement the market economy where approximately 50 percent of the work force is employed in cod fishing. Electricity, introduced in the early 1960s, impacted subsistence activities by allowing residents to store meat in freezers throughout winter. Residents still value wild birds and eggs as sources of fresh food; they value the preparation and consumption of a meal of birds as an important tradition. But the rapidly evolving economy, with its emphasis on unemployment insurance, enables residents to acquire cash for fuel and ammunition plus free time to engage in recreational hunting. Wildlife regulations are often disregarded, while behavior is tempered by group norms and personal ethics.

Methodology

With backing from the Canadian Wildlife Service (CWS), QLF launched its Marine Bird Conservation Project in 1978 with the goal of helping to restore depleted wildlife populations by reducing the threat of illegal harvest in a manner sensitive to the local culture. The objectives presumed that a lasting reduction in illegal harvest depended on more than police power restrictions and an information-based education program. The objectives were to do the following: (1) teach practical seabird biology and conservation principles, (2) encourage the development of a conservation ethic, (3) train residents to take an active role in conservation, and (4) build local support for wildlife policies and regulations (Blanchard 1987). Because of the potentially antagonistic message the programs would carry, concepts known to conflict with social patterns and ethics were introduced in a low-key manner involving local leadership.

Youth Programs

The cornerstone strategy was a four-day, experiential, youth conservation program at the St. Mary's Islands Seabird Sanctuary, 13 kilometers from the village of Harrington Harbour. Using a former lightstation as classroom and dormitory, the program provided hands-on instruction in seabird biology, sanctuary etiquette and wildlife law to youth from families experienced in bird or egg harvest. The curriculum emphasized biological and human factors affecting breeding success in seabirds. Participants took field trips twice daily to the seabird colonies and interacted with student instructors, visiting wardens and biologists. Lesson plans utilized local dialect and norms. Participants returned to their families with increased knowledge and greater concern about seabirds (Hallowell 1985). The program received universal acclaim among families and schools, cooperation from local businesses and support from Canadian foundations.

Beginning in 1983, summer youth programs started in five villages for children who were unable to travel to the St. Mary's Islands. These conservation clubs, such as the "Hawkeyes," were led by university students and local teenagers hired under federal employment grants. The programs received widespread parental support.

In one village, where local attitudes toward conservation were most hostile, project staff produced a play for children in which the actors, who in real life were the sons and daughters of local poachers, played the major roles of seabirds. By practicing their lines at home, these children taught their parents about the biology and conservation of seabirds and won their support for the project following performances in their village and neighboring communities.

With supplemental funding from a Quebec provincial agency and Wildlife Habitat Canada from 1985 to 1988, project staff made presentations in schools of every village from Aguanish to Blanc-Sablon. The presentations focused around a specially produced slide-tape program (Hallowell 1985), seabird workbook (Lageux 1985) and a poster and poem contest about seabirds. The contest culminated in a final judging by representatives of five Canadian conservation organizations and the production of a 1989 calendar of children's wildlife art.

Leadership Training

With grants from Employment and Immigration Canada between 1983 and 1989, more than 40 local volunteer and paid staff were trained in field research, teaching, species identification and community work. Many local students returned to work for several summers; one described the experience as "life changing." There is universal parental support for the obvious contributions to student employment.

Leadership support was provided to well-respected members of Harrington Harbour, who in 1984 organized the first coast-wide society for wildlife conservation and cultural preservation. The Quebec-Labrador Foundation provided technical assistance and a major grant towards the refurbishing of an historic building, using local labor, as the society's headquarters.

Presently, QLF and CWS are working with the local wildlife society to assume co-ownership of one of the St. Mary's lightstation buildings—an action perceived locally and abroad as a commitment to a shared responsibility for the well-being of the sanctuary . Building restoration is in progress, with help from Transport Canada, CWS, foundation support to QLF, and local skilled labor. The mutual goal for the facility is to maintain it as a research, education and conservation laboratory. It will be managed locally as a facility for researchers, university students, wardens and local youth. Supplemental income will be derived from a limited tourism operation.

Information and Education Materials

The use of posters, pamphlets, signs and other printed materials to introduce wildlife concepts and regulations was given lower priority in an effort to emphasize a more personal, empathetic and interactive style of education. The average educational level among heads-of-households along the Lower North Shore was grade 7 (Blanchard 1984); communication was largely by spoken word. Therefore, printed materials were introduced gradually, in a low-key manner, and distributed door-to-door, in schools and in community stores. They were produced using colloquial names for birds, abundant illustrations and cartoons, and recognizable place names.

The materials included: (1) a seabird poster on identification, biology, and laws protecting nongame; (2) a slide-tape program utilizing local scenes, persons, and customs; (3) a citizen's guide, "Seabird Conservation: It's Up to Us," with forewords by leaders from English and French communities; (4) a newsletter for elementary schoolchildren; and (5) a 1989 calendar of children's wildlife art and poetry. All materials were well-received locally and outside the region.

Broadening Support for Conservation

Study tours to the sanctuaries were conducted in 1983, 1984 and 1987 in order to stimulate local interest in deriving income from tourism, heighten perceived value of the resource, and broaden responsibility for the sustainability of the resource and long-term maintenance of local culture. Representatives of several Canadian conservation organizations were selected for the thematic tours, which focused on the anniversaries of visits by John James Audubon and Jacques Cartier and the establishment of wildlife sanctuaries in Canada. Homestays in a remote village and public forums on the seabird issue were vital components of the study tours. The tours generated new income for conservation, inspired local action, heightened the perceived value of seabirds, and fostered alliances between local and regional conservation organizations.

In cooperation with QLF, the Canadian Broadcasting Corporation produced documentary film and radio programs which helped broaden the support nationwide. In the 1987 film *Home of the Birds* (The Nature of Things production) and a 1989 nine-part documentary radio series, coastal residents served the leading roles. The productions documented important local norms and concerns plus triggered interest among politicians, conservationists and the general public in conservation on the coast.

Since 1978, more than 100 presentations about QLF's Marine Bird Conservation Project have been made to universities, colleges, conservation organizations and schools in North America and abroad, in an effort to promote the importance of local involvement in wildlife conservation. These lectures have generated a constant influx of top-notch university students as instructors and researchers on the project. Students' character, enthusiasm and empathy toward local people are important ingredients to the project's effectiveness.

Results

Results of the Marine Bird Conservation Project are measured in terms of changes between 1978 and 1989 in the following: (1) population levels for seabirds nesting in sanctuaries; (2) knowledge, attitudes, and hunting behavior of residents; (3) management policy by CWS; and (4) local involvement in conservation.

Changes in Populations of Nesting Seabirds

As reported by CWS, between 1977 and 1988, increases occurred in all families of birds nesting in sanctuaries of the Quebec North Shore. Most notable of the increases occurred among the alcids: common murre increased from approximately 10,200 to 26,000 individuals; razorbill increased form 3,600 to 7,000; Atlantic puffin increased from approximately 15,200 to 35,100. Increases also occurred for common eider, 3,000 to 8,500, and common and arctic tern (*Sternus* sp.), 1,500 to 2,000 (Chapdelaine and Brousseau in press). Populations of seabirds nesting in sancturaries of the North Shore of the Gulf of St. Lawrence have been surveyed on a five-year basis since 1925 (Lewis 1925, 1931, 1937, 1942, Tener 1951, Lemieux 1956, Moisan 1962, Moisan and Fyfe 1967, Nettleship and Locke 1973, Chapdelaine 1980, Chapdelaine and Brousseau 1984, Chapdelaine and Brousseau in press). The current upswing in population levels for most species is a significant change from the serious declines experienced between 1955 and 1978.

Changes in Local Knowledge, Attitudes and Hunting Behavior

Results of a follow-up survey of heads-of-households conducted by QLF in 1988 showed several significant changes in local knowledge of wildlife law, attitudes toward hunting and regulations, and level of harvest of birds and eggs. The percentages of respondents which correctly stated the legal status (i.e., game versus nongame) for Atlantic puffin was 76.5 in 1988, as compared with 70.7 in 1981 ($p = 0.0$, $X^2 = 16.0$); the percentage which correctly stated the legal status for razorbill was 70.3 in 1988, 62.1 in 1981 ($p = 0.0$, $X^2 = 22.9$); the percentage which correctly stated the legal status for common murre was 64.1 in 1988, 47.1 in 1981 ($p = 0.0$, $X^2 = 26.3$); and the percentage which correctly stated the legal status for herring gull (*Larus argentatus*) was 79.3 in 1988, 78.6 in 1981 ($p = 0.009$, $X^2 = 9.35$). The vast majority of respondents in both years knew the legal status for common eider.

The percentage of respondents which believed these five species were important increased; common eider was still considered important by the highest percent of respondents (97.2 in 1988, 87.1 in 1981). The percentage of respondents which believed it is "okay" to take seabirds and eggs for food dropped significantly from 95.0 in 1981 to 89.6 in 1988 ($p = 0.039$, $X^2 = 6.5$). The percentage of respondents which believed that it should be legal to hunt puffin dropped significantly from 54.3 in 1981 to 26.9 in 1988 ($p = 0.0$, $X^2 = 22.22$); the percentage which believed it should be legal to hunt razorbill dropped from 58.5 in 1981 to 37.9 in 1988 ($p = 0.002$, $X^2 = 12.53$); and the percentage which believed it should be legal to hunt common murre dropped from 76.4 in 1981 to 64.8 in 1988 ($p = 0.038$, $X^2 = 6.56$). There were no significant changes in the percentages which believed that it should be legal to hunt common eider (91.4 in 1981, 91.0 in 1988, $p = 0.276$, $X^2 = 2.57$) or herring gull (46.4 in 1981, 33.1 in 1988, $p = 0.051$, $X^2 = 7.75$).

Despite the continued belief that birds should be harvested, individuals' behavioral intention changed dramatically. The mean response to the question, "What percent of families in your village harvest seabirds and eggs," dropped significantly from 76.27 percent in 1981 to 48.02 percent in 1988 ($p = 0.0001$, $t = 7.19$). The average number of birds reported as needed per year by families dropped from 43.98 in 1981 to 23.58 in 1988 ($p = 0.0078$, $t = 2.68$). The percentage which claimed their families needed birds for food declined from 51.4 in 1981 to 28.9 in 1988 ($p = 0.0$, $X^2 = 27.2$); the percentage which claimed they needed wild eggs dropped from 14.2 in 1981 to 7.6 in 1988 ($p = 0.0$, $X^2 = 19.8$).

There were few changes in demographic variables for respondents to the 1988 versus 1981 surveys. The mean number of years residence on the coast was 44.6 in 1988, 44.1 in 1981. There was a mean of 3.8 occupants per household in 1988, 4.8 in 1981. There were about 10 percent fewer fishermen drawn in the 1988 sample ($n = 140$).

Changes in Management Policy

Changes in CWS management policy between 1978 and 1989 with respect to seabird populations of the Quebec North Shore showed increased funding, greater number of enforcement officers and increased cooperation with other federal and provincial agencies. The number of federal migratory bird wardens increased from one in 1986 to six seasonal wardens or assistants beginning in 1987. There was strong collaboration with the Canadian Parks Service in patrolling two sanctuaries. There was increased funding for research into the productivity levels for some species. Conservation education programs by QLF were given greater support. There was meaningful collaboration with local residents. These changes reflect a return to the comprehensive management philosophy of Harrison Lewis, which characterized the period 1925 to 1955, and recognition of the important role of education and local involvement in restoring wildlife populations.

Greater Public Involvement

Membership in the local wildlife society has grown since its incorporation in 1984. Approximately six local teenagers apply for summer jobs in conservation each year. During the past five years, there has been approximately double the demand locally for the St. Mary's Island youth program. Membership in the youth conservation clubs has grown. Citizens of Harrington Harbour are helping to protect the buildings at St. Mary's Island. There is increased interest in the seabird resource for tourism development. Increasing numbers of citizens are outspoken about conservation on radio and television.

Discussion

Why did the knowledge, attitudes and behavior of residents change, especially in the face of research that indicates education programs do little to change attitudes and behavior? There are many models which specify the variables that account for behavior but few models reliably predict behavior changes after the manipulation of the variables (Fishbein 1967, Hines et al. 1986–87, DeYoung 1985–86). Several key variables include the following: (1) knowledge of the problem (i.e., why a change should be considered); (2) knowledge of what to do (i.e., how the change should be implemented); (3) attitudes specific to the behavior and consonant with the change; (4) feelings of competence and confidence in one's ability to implement the change, and the sense that one's new behavior will make a difference in the problem; (5) intrinsic motivations, such as compliance with social norms that support the new behavior or internal satisfaction such as frugality; (6) modeling of the new behavior, as by community leadership; and (7) extrinsic motivations, such as fines, punishments or other incentives for immediate changes.

Most education programs only provide information in an attempt to change attitudes without regard for social norms, group leaders, communication channels, intrinsic motivations, etc. Actually, most education programs try to reach such a diverse audience that these elements are rarely identified, known, or manipulatable.

On the Lower North Shore, some of the same factors that created a difficult environment for enforcement to operate effectively were conducive to producing a successful educational program: aspects of geography, local tradition, group norms, lack of short-term extrinsic incentives, and the lack of reactance-inducing enforcement. The relative isolation of the small villages meant there was little competition for extracurricular activities for youth, and they were eager to try new programs. The local tradition strongly supported killing only as many birds as were needed so the populations would not be decimated. Several community leaders were deeply concerned about the current status of the bird populations, and, as Katz and Lazarsfeld (1955) would suggest, this type of influence in small communities is critical. Most heads of households shared their concern: 71 percent were either somewhat or very concerned about the future number of seabirds along the coast (Blanchard 1984).

One of the most serious limitations of extrinsic incentive-based efforts to change behavior is that they have regularly failed to produce durable, long-term change in behavior (Katzev and Pardini 1987–88). Furthermore, heavy-handed enforcement, a form of strong extrinsic motivation, is not just unlikely to produce durable change, it is also likely to trigger reactance which induces behavior in the opposite direction: people devise means for getting around the imposed rules (Brehm 1966, Brehm and Brehm 1981). On the Lower North Shore, this could be seen in the form of night raids to the seabird colonies for eggs. Durable behavior change requires the use of other techniques—social commitment (Katvez and Johnson 1987), intrinsic behavior (DeYoung 1985–86, DeYoung and Kaplan 1985–86), supporting attitudes (Heberlein 1981) alone or in combination.

In addition, other opportunities for producing a successful educational program existed. For 25 years, the founder of QLF served as minister, floatplane pilot, and leader in social service programs for residents. He was accepted as an integral member of the local communities. Because the average village population consisted of 350 long-term residents, new ideas were quickly disseminated through well-worn communication channels to a large percentage of community residents, a process described by Rogers and Shoemaker (1971).

In this case, the communities along the Lower North Shore were small, cohesive units, the group leaders were easily identified, and the social norms that supported the behavior change could be identified and enhanced. Because the educational program did not begin with the faceless force of authority, but rather, was introduced by a known and respected leader and implemented by students and local youth, it was initially accepted. Although the youth programs directly worked with youngsters, several elements of the programs were designed to involve families and other adults. Not wanting to be left out of a new community ethic, many adults, no doubt, were quite interested in learning along with their children.

Neither did the educational programs attempt to change behavior unilaterally. Rather, the youth programs were one element of a campaign designed to enable community leaders to influence other adults through community meetings, local art and music events, television and radio programs, and employment opportunities.

Another difference between this program and others may be that stopping a behavior (e.g., poaching) and substituting a behavior (e.g., another form of recreation) are different from beginning a new one (e.g., eiderdown collecting). The image of beginning a new behavior may connote helplessness or uncertainty if participants perceive the behavior to be difficult or out-of-the-ordinary. If substitutes are available, however, ending an existing behavior requires that the individual and/or community justify and support the change.

Results of the harvest/attitude survey suggest that the educational programs did not convince participants that it is wrong to kill birds, but rather took advantage of the double-edged hunting tradition that also taught that is is wrong to take more than one needs. With modern transportation and food storage, the need to harvest birds declined, but it took the educational programs to make evident this change and conflict between tradition and behavior. Information about bird population biology that reached and was accepted by the entire community helped change the social norm away from approval of widespread seabird harvest. Note that the data report a change in the harvesting behavior of "others in my village." This indicates that the respondents are aware of others' behavior and this knowledge is likely to have an effect on their own.

Results also suggest that residents are better informed about regulation and understand the rationale behind them. However, the basic norm remains the same: it is acceptable to harvest birds for an occasional meal, especially if they are needed as food. The large drop in the percentage of respondents which believe it should be legal to hunt puffins may be partly explained by the increasing aesthetic value residents place on that species. A larger percentage still believe that it should be legal to hunt murres probably because there is a season on murres for residents of nearby Newfoundland and Labrador.

Chapdelaine and Brousseau (in press) cite other possible explanations for changes in the populations of nesting seabirds: immigration among common eider and changes in the supply of prey fish. Nonetheless, these factors do not detract from the obvious impact of controlling the hunting factor.

Conclusion

Educational programs along the Quebec Lower North Shore were part of a campaign to motivate the public to conserve their seabird populations and were complemented by an increased enforcement presence by the CWS. Although many of the programs targeted youth, the educational message reinforced the traditional conservation practice. This practice and concern was voiced by respected community leaders, whose efforts to mobilize the local wildlife society reinforced the educational programs. Youth employment opportunities and study tours voice the same message, while supporting the local economy and helping the villagers take pride in their wildlife resource.

The increase in police power enforcement probably had significant impact on the control of illegal harvest during the period 1978–1989. However, the introduction of extrinsic motivation without regard to other factors—e.g., communication channels, group leaders, social norms, intrinsic motivation—can be expected to either fail by producing reactance or produce ''quick-fix'' that lasts as long as the incentive. In this case, knowledge, attitudes, and behaviors of residents changed with respect to harvesting seabirds. The educational programs were part of the intervention that seemed to make the difference. But this campaign to change knowledge, attitudes, and behaviors was integrally woven into the web of the local culture, such that the success of the program cannot belong to the information effort alone.

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Special Session 3. *Trends of Professionalism in Natural Resource Management*

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Professionalism: From Matriculation to Success

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Introduction

Professional expectations are rapidly changing. Not only are new resource problems developing, but agencies adjust their approaches to addressing them, and, in turn, universities alter curricula and courses to better prepare graduates to become natural resource professionals. Nevertheless, the profession itself remains dissatisfied with the status and progress of the profession—professionalism isn't what it ought to be—and the blame is tossed about like a hot potato. Universities, employers (not just agencies), professional societies, and the professional, too, share in the responsibility.

Gilbert (1971) in his classic discussion of professionalism, defined a profession as "an occupation that requires specialized knowledge, is distinguished by devotion to people, is aware of its public image, has status, is organized as a society, functions as a unit, and is determined to be respectable and respected." We would like to emphasize his point relative to unit function. Gilbert specifically indicated that "management, research, public relations, and administration must move forward as an integrated whole." We would certainly add "education" to this list.

Our purpose in this paper is to pose a series of questions about the status of professionalism in our profession, and how the various players must function as a unit, rather than individually, to make real progress. Some of the issues will be specifically addressed in some of the papers of the session, others will remain for future discussion.

Before delving into the issues, we would like to return to Gilbert (1971) for his characterization of the professional, a term he said "infers excellence." His list of characteristics included the following: capability (including creativity), tolerance and understanding (individually and between disciplines), tact, flexibility, self-analysis and criticism, dignity, ability to communicate, devotion to duty and honesty, and, finally, willingness to help others. Obviously, if the professional is to exhibit all these characteristics—most of which are personal—the most important player is the individual. Then the role of the other players—universities, employers, and societies—must be to provide the atmosphere for professionalism to be cultured and exercised. The resultant excellence will mutually benefit the resource, the public, the employer, the professional and the profession.

The Nestling (America's Youth)

As we look back at our college days, we find a rather stereotyped group of fisheries and wildlife students: mostly men of rural background, experienced in the outdoors, and likely devoted hunters and anglers. This background produced a matriculating student who was pretty good with his hands, who appreciated the productivity of the land and the ability to manipulate it and channel that productivity for the good of man, who respected the unpredictability of nature, and who realized that sustained yields were possible, This individual was probably attracted to the curriculum by an interest in game management and a desire to work in the outdoors.

The wildlife student of today is anything but a stereotype. The prospective student, male or female, is more apt to be from an urban background, may have an interest developed through television programs or outdoor activities such as camping, boating and canoeing, and frequently has never participated in hunting and fishing. This student also has outdoor employment as a strong motivation, but is about as likely to be attracted to the curriculum by a desire to save the earth's wildlife from development and habitat degradation as by an interest in consumptive use of renewable natural resources. This diversity is good for the profession, but poses some challenges to the educators, employers and professional societies later in professional life.

But must we wait until later? As a profession, shouldn't we be nurturing the hatchling? We're quite sure we can. Obviously others also believe we can. Project WILD, Aquatic WILD, Project Learning Tree and others are reaching teachers and youth with sound principles and impressive experiences. Adams and Thomas (1986) recommended direct involvement of our profession in teacher training, but warned that teachers and classroom experiences were typically minor influences on students' interest in wildlife. Last year's conference on developing and implementing Aquatic WILD illustrated the uncertainty of how to successfully carry out such a program. Sponsorship and input from the fisheries and wildlife profession were integral to its success.

Nevertheless, secondary education programs target the general student public, as is badly needed, with only trickle-down effects on future professionals in our field. Who is to ensure that the youth who ought to pursue a life in our profession will actually find us? How can we help those who are headed for our field to be better prepared before they matriculate?

In recent years, we haven't worried much about recruitment, since there has been an abundance of students enrolling, and graduating, despite the decline from the 1970s (Hodgson 1987). Nevertheless, our profession has always had a need and place for the exceptional individual, and our curricula have always welcomed the qualified applicant. Early identification and involvement of these individuals is necessary if we are to impact their view of opportunities in our profession. Such activities as natural resource camps, wildlife clubs, and 4-H can afford some of the historically-important experiences. However, it is not unusual to encounter students who have been discouraged from entering our field by practicing professionals, who may believe that jobs are lacking, opportunities for professional expression stymied, or that rewards are not commensurate with the education and responsibility required. On the other hand, our professional societies have assisted tremendously through the development of brochures which objectively describe the opportunities and challenges for employment in our field. Nevertheless, it is not uncommon to encounter newly-enrolled freshmen who are amazed that there is actually a curriculum that one can pursue to become a fisheries and wildlife scientist.

Promotion of natural resource conservation as a field of study is also a necessity if we are to attract minority students and produce minority graduates to fill the positions in our profession that employers are increasingly demanding. During the 1980s, when students were generally drawn away from the environmental and natural resource curricula to business and engineering, minority students seldom chose to enter fisheries and wildlife (or related) curricula. A recent survey by the Association of University Fisheries and Wildlife Program Administrators showed that only about 2% of our undergraduate enrollment consisted of minorities.

We cannot ignore the pending professionals during their formative years. We must impact their view of our profession through information and education programs and actively attract them into our curricula. This education and recruitment of future professionals from the secondary schools cannot be sole responsibility the universities; the profession needs to work as a unit if progress is to be made.

The Fledgling (The College Student)

The body is developed but the mind is naive. Independence must be established, one must explore, one must learn the requisites of survival. This is a period of high impressionability. This is a period of personal, cultural and technical growth, a period during which the individual develops the characteristics of a professional. The fledgling professionals become the sole responsibility of the university faculty for a period of four or more years, during which they are to be nurtured to maturity. What an astounding responsibility for these new foster parents, who accept into their home the youth of many backgrounds, motivations and aspirations! Like most parents, the university professional has many constraints and gets lots of advice on how to bring the fledgling to maturity.

Like the divergent positions on child discipline, the profession exhibits diverse views on what curriculum should be, especially at the undergraduate level. Much of this debate centers around the distinction between education and training. Recent internal emphasis on liberal education as a part of all students' curricula has led to core course requirements, which in turn limit the opportunity for specialization and selection of elective courses. (We should note here that one pervasive core course requirement is in ethics, a topic to be discussed later.) In light of the fact that professional-level positions in fisheries and wildlife, and other natural resource professions, are filled primarily with candidates holding advanced degrees, some (e.g., Oglesby and Krueger 1989) argue that specialized undergraduate degrees are inappropriate in our field. In contrast, a recent evaluation by a committee of the American Fisheries Society concluded that our curricula can successfully meet both the educational objectives of the core curriculum as well as the specialized training in natural resource science (Adelman et al. 1990). Presumably, this mix allows us to produce graduates who are both "thinkers" and "doers."

Certainly we have disagreement over what the "doers" ought to be technically competent to do when they are handed their undergraduate degrees. Educators generally feel that knowledge of principles and contemporary techniques, coupled with experience (inside and outside the classroom) in communication, problem-solving and decision making are essential ingredients for the graduate. With these skills, the graduate should be adaptable to a variety of job opportunities and should be able to function in an interdisciplinary world. In contrast, employers frequently suggest that it is the university's responsibility to ensure that the graduate can operate an outboard motor, standard transmission vehicle and telemetry receiver. Our professional societies additionally prescribe the coursework requirements for certification as Wildlife Biologist and Fisheries Scientist (note the difference in terminology) which have been generally agreed upon by our society memberships (even though a minority of our members themselves are actually certified). Most universities take these standards seriously and either require graduates to meet them or at least have the appropriate courses available. Nevertheless, we must all recognize that not all graduates of our curricula intend to be professional wildlife biologists or fisheries scientists, so should we impose these requirements on them?

For the student to mature as a professional, experiences outside the classroom are particularly important. Faculty advising, both formal and informal, is critical, especially with regard to professional opportunities, and how to prepare for them. We found that when we developed an elective course on career development (Slack et al. 1982), students actively sought it out, and used the material offered for their professional development. It is in this same regard that exposure to extra-university professionals in the form of internships is so influential. Although such opportunities are readily available in conservation education and some other outdoor areas, relatively few such positions are available with the resource management agencies. Those agencies who use the internship and cooperative education approaches are regularly employing these graduates; obviously they are finding that the degree requirements, supplemented by experience with them, are able to produce the kind of employee that they want. We do not view the recent proliferation of volunteer internships as consistent with professionalism. The undergraduate major, underclassman or upperclassman, is due a day's pay for a day's work. Is their first "real" experience with our agencies to indicate otherwise?

We agree with Peek (1989) that our graduates are better educated than their predecessors, and that the diversity we attract and produce is healthy for our profession. However, we question whether the profession provides a mechanism for them to attain professional positions unless they go directly to (or back to) graduate school to acquire an advanced degree.

Since entrance to professional positions in agencies typically occurs with the advanced degree, professional development at the graduate level must be addressed. We must recognize that for most students, the personal characteristics involved in professionalism (most on Gilbert's list) will be well developed, perhaps almost fixed, by the time of entry to graduate school. At this level, the technical skills and ability to integrate them, will be cultured.

A continuing, perhaps justified, criticism of the advanced graduate's capability is the strong bent toward research, when so frequently professional employment will be principally resource management. Although some universities provide degree opportunities in non-research, "professional" degrees, which combine coursework with a managerial internship, relatively few Master's candidates choose this alternative. The arguments that the thesis option is a proven commodity and that the non-thesis degree is likely to be viewed as terminal (precluding further graduate degree candidacy) prevail in the minds of potential graduate students. On the other hand, professors may be less inclined to advise non-thesis students, whose work will not likely lead to another scientific publication.

In contrast to the undergraduate degree, the Master's degree should have a greater emphasis on training—developing the technical competencies needed for professional effectiveness. Some disagreement still prevails concerning what is "proper" training at the graduate level. After more than a decade of debate and trial-and-error, the Southeastern Section of The Wildlife Society has implemented a graduate accreditation program to identify those institutions which supposedly are capable of producing highly-trained professionals at the Master's level. Rather than specify the courses which should be offered, this program examines human and fiscal resources, experience of faculty, and placement record of graduates. This approach has allowed university programs to maintain their individuality and flexibility, thereby producing graduates who are not necessarily stereotypes. The profession generally has wrestled with the accreditation issue for over 50 years (Swank 1987), but has chosen to retain the stance (and effects) of dealing with professional competence through certification programs.

The graduate degree may be the logical degree level at which progress can be made in attracting and training minority professionals. Our institutions have a variety of discipline heritages. Some have grown out of biological sciences, others out of associated natural resources. Consequently, we can still recruit graduates who have pursued these sciences, as well as graduates from undergraduate curricula in fisheries and wildlife, where minority enrollment is low. Brown (1988), in his summary report for the American Fisheries Society's Equal Opportunity Committee, emphasized the potential for establishing linkages with historically black colleges and universities to produce minority graduates, both for employment and for graduate school. Involvement of all components of our profession would be necessary—another example of a unified approach to professional development.

The Adult (The Practicing Professional)

Agency employers continue to seek graduates with traditional skills to assume responsibilities which are increasingly non-traditional. Although managers deal largely with interdisciplinary projects which require knowledge of socioeconomic principles and skills in organization and interpersonal relationships, position announcements indicate preference for knowledge of natural resource ecology and skills in field operations. The employer must ensure that the employee can grow into the type of professional responsibilities that will be encountered.

But what is the professional future of the person employed with the bachelor's degree? Even if the employee has the personal and technical abilities, advancement is stymied by a host of Master's degreed colleagues. Continuing education is a must if the undergraduate education is not to be wasted by entry-level stagnation.

The professional with the advanced degree is equally in need of continuing education. Many of the techniques learned in school will quickly go out of date. Other skills, e.g., personnel management and biopolitical savvy, will need to be developed. Although agencies are now recognizing a responsibility for in-service training, this role has been slow to develop.

Approaches to continuing education are varied, and the results probably equally variable. Career development leaves (sending the employee back for another degree) seem to have gone out of vogue, and have been replaced by formal in-service programs developed by the agencies themselves. Perhaps this says something about agency perceptions of the abilities of universities in some areas of endeavor. Programs which encourage participation in externally-developed shortcourses, workshops, symposia and scientific meetings, whether offering formal Continuing Education Units or not, provide the opportunity for a diversity of skills to be updated (or acquired). These two approaches exemplify a dichotomy of philosophies: the former allows the agency to give the professional what it thinks is needed; the latter allows the individual to seek out topics of greatest personal interest.

Continuing education must not be restricted to technical skills. Recall that Gilbert's (1971) criteria for the professional were mostly personal ones. Although technical subjects are appropriate, continuing education should include modern principles and exposure to philosophies, contemporary issues and ethical behavior for professionals. The Wildlife Society's newly-adopted Professional Development Program recognizes the need for continuing education to be broad. The certificate requirement that the 150 contact hours be spread over six categories will ensure that more than further specialization is achieved.

The Harvest

The professional displays excellence (Gilbert 1971); effectiveness, as a result of commitment, characterizes the professional and distinguishes a vocation from a job (Thomas 1986). Commitment, a personal attribute, should lead to the endless pursuit of skills needed for excellence. In addition to personal and technical competence, however, ethical behavior is an integral part of professionalism. Certainly within the scientific community, questionable ethics have been more damaging to our public image than our occasional errors in making management decisions. As the resource manager interacts with colleagues, constitutents and the resource itself, the highest of ethical standards must be upheld. One cannot legislate ethics, but that seed is being sown at the undergraduate level, and employers must reinforce ethical behavior and be prepared to objectively maintain and reward high standards of performance.

A sense of professionalism lies solely with the individual (Thomas 1986), but that sense is influenced externally. Early perceptions are the result of society's emphases, which are delivered via schools and the media. Are the professional societies and employers actively influencing society's priorities? Colleges and universities educate and train. Is the result really one who can both think and do? Are future employers providing their share of education and training to students via internships? The graduate is ill-prepared to function in a technologically and politically changing world a generation from now. Can our profession provide the opportunity for continuing the professional's growth—for the benefit of self, employer, resource, profession and society? We must display a professional approach to professional development—we must move together as a unit.

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University Education in Wildlife Biology: What's Given and What's Needed

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Tremendous changes have occurred in the last two decades that affect the future of wildlife resources; changes that require constantly rethinking the nature and definition of not only wildlife management, conservation and research, but also wildlife education. The number of new laws has been staggering—the National Environmental Policy Act, Endangered Species Act, Marine Mammal Protection Act, Federal Water Pollution Control Act, National Forest Management Act, Food Security Act of 1985 and the Clean Water Act Amendments of 1986 are just a few. In addition, hundreds of local laws have added new dimensions to wildlife conservation, to say nothing about the proliferation of legal decisions affecting the resource and how it is used.

Further, trends in human population numbers and distributions, along with their associated environmental impacts and resource allocation problems, pose continually changing problems and will require greater participation of wildlife professionals at all levels—local, state or provincial, federal and international. With a global population of 5.2 billion predicted to increase a billion in each of the next three or four 12-year periods, conservation has to take on different dimensions to succeed.

Unfortunately, the number of wildlife positions has not and will not increase at a rate that will meet these escalating and diversifying demands. We believe that university wildlife programs must be dynamic and forwardlooking as the only way to position graduates to take full advantage of the opportunities and challenges before us and the only way we will be able to perpetuate wildlife resources and meet public expectations.

We wish to make a statement from the perspective of agencies' needs and what they perceive they get in a graduate. Our perceptions are based on considerable experience in university education programs and, perhaps more important, in employing graduates for work with state and federal agencies, and from serving on review teams of university research and educational programs. One of us has been responsible for conducting shortcourses for young and mid-career wildlife biologists frustrated by ineffectiveness in influencing natural resources management.

In the past decade and especially within the last two years, education in wildlife biology has drawn the attention of a number of educators. We have read with keen interest and appreciation the papers by Capen, Teer, Edwards, Gavin, Bolen, Wagner, and Peek in the fall 1989 issue of The Wildlife Society Bulletin. All are university professors, which almost by definition means they hold doctoral degrees.

By contrast, education in wildlife biology and management has been addressed in the literature by only a very few practitioners of wildlife biology or by those who employ them (*see* Cookingham et al. 1980, Cutler 1982, Yoakum and Zagata 1982, Lyons and Franklin 1987).

University education in wildlife biology has had from its inception a strong emphasis toward field research. The strength of this approach is that if a person can collect data, evaluate them and publish the results, he or she will be expert in its application. We do not accept this approach hands down.

We hasten to add that research is absolutely necessary to wise management; scientific truth should and must undergird management now and in the future. Our concern is that research alone is not enough. We believe that the research orientation largely has overshadowed if not excluded other areas of conservation endeavor in crowded biology curricula. The effects of habitat loss, degredation and fragmentation; pollution in its myriad of forms; long-term exploitation of resources; and the rapidly changing values for which wildlife are managed all require both research and management. Further, these conservation and environmental issues constitute increasingly difficult resource decisions involving many value judgements, both biological and non-biological. Thus we submit the proposition that a great need exists to broaden university education in wildlife biology and conservation.

Education programs originally were steeped in natural history, systematics, zoogeography, autecology and descriptive biology. Over time emphasis has evolved on the hard sciences and mathematics. Advances in understanding of function, process and result in community and population ecology have provided the basis for evolving management techniques and strategies. The age of information and its management is here. Instrumentation now is available for obtaining large quantities of data of increasing quality that provide mountains of grist for analysis in constantly improving computer technology. Results from research from such advances, and the technology itself, have revolutionized the field.

We now see departments of wildlife biology given over to mathematical studies of populations (models and simulations), to genetics and evolutionary relationships of species and populations, to biotechnology, and to other important subjects that do not always serve the day-to-day needs of management agencies or their employees. Further, missions of conservation and environmental protection agencies differ markedly. To be sure, graduates going into research are better equipped than ever before, but they are not equipped well to satisfy management work in state and federal agencies and the private sector whose interest and charge is protection of environmental quality. With a strong research education mode, the question becomes, "now that we've developed the high-yielding tomato, who knows how to plant tomatoes?"

Undergraduate curricula are properly science-oriented and that starts the process of infusing the student with a research orientation. Research is reinforced with focus on originality and independence in advanced degree programs with thesis and/or dissertation requirements. Further, most university faculty of wildlife biology are themselves oriented to research by training and experience and, in turn, influence students by word and example. Thus the character of wildlife education is self-perpetuating, and the result is many graduates in wildlife biology consider themselves first as research scientists and secondly as managers of the land and wildlife. In some respects universities have created a "school of menhaden," all fashioned alike and expecting to do research as their major responsibility.

Herein lies the dilemma. Are we training wildlife biologists to be research scientists or are we training them to apply their science as managers of land, wildlife and people? Is there a dichotomy between scientists and scientist/conservationists and do universities recognize the dichotomy in their educational programs? With such a late hour in a wildlife world at risk, is it not time to feature application of research and to broaden the students' perspectives into other fields of human interest rather than to educate them to practice strict science while the barn door of conservation effort is ajar?

What of the vast majority that go by choice or circumstance into management positions? The young biologist finishing a master's degree program and gaining employment with a management agency does not collect vast amounts of complex data and sieve through it in search of fundamental scientific truth or generality. Rather, they deal with a world of management that requires fundamental skills in gathering data in uncontrolled conditions, analyzing them, and putting the results into management action in a world of political, fiscal, cultural and land capability realities.

Hooper (1986) received opinions on continuing education interests of 125 Associate and Certified Wildlife Biologists from membership lists of the Western Section of The Wildlife Society. Out of 27 topics listed by respondents who had attended some form of continuing education program in the past five years, habitat assessment ranked number one. Riparian habitat management, fire management, deer management, waterfowl management, range, management, computer programming and computer applications were ranked through the next eight places.

Respondents in Hooper's (1986) survey also ranked knowledge deficiencies in writing skills, interpersonal communication, public relations, conflict resolution, political processes, public speaking, and habitat assessment and manipulation in the top levels of need.

Although the sample is small and regional, we infer from Hooper's data that wildlife biologists are more interested in the application of management than in many other topics currently available in workshops, symposia and inservice training.

We submit that wildlife education in most universities and colleges does not adequately fill the needs of young professionals or the agencies that hire them. Universities have, conversely, adapted well to training young men and women in the new technology and to its application in research. Most employers need biologists who can perform basic field tasks and interpret results into management action with an understanding of the underlying science. Moving that information into management action requires knowledge of other fields such as forestry or range management, ability to negotiate and compromise, and skill in exploiting whatever the "system" is that defines the management arena.

The vast majority of wildlife biology graduates are employed by state and federal agencies and the private sector to manage wildlife and other natural resources. They manage land, enforce law, control wildlife damage, educate private landowners, assess habitat alterations, and bring conservation programs to citizens. Their responsibilities do no include fundamental research even though they must gather biological data and evaluate it for making decisions about management. When field investigations are assigned, they are usually short-term and mission-oriented.

They are required to manage the land and wildlife for its own sake as well as that of people who use it. But biological data are not the only facts that enter into the decision process. Many are asked to evaluate and correct environmental insults, to educate society and communicate an appreciation of the natural world, to develop strategies for protecting scarce life and especially to produce wildlife for both nonconsumptive and consumptive uses—all in the context of the human condition.

We see a renewed interest among several sectors of the scientific community to put science to work for conservation. We herald this trend and feel we must cause students to enlarge their scope beyond traditional biological sciences. We must encourage them to cross into management phases of conservation and to cross over into other fields of human interest. Science without application is a luxury that wildlife resources and the human environment cannot afford.

Universities and agencies share the responsibilities of making this expansion from research-oriented curricula to research/management orientation curricula. Such activities require basic skills in the acquisition and analysis of data, evaluation of actions, synthesis of information, formulation and execution of management action, ability to operate effectively in teams, and to deal in the arena defined by law, regulations and politics. Social, economic, political and cultural backgrounds define problems. Biology alone cannot solve them (Deshmukh 1989, Wilkins et al. 1989, and Harris 1990).

When called to question on such grounds, university faculties often defend their curricula and educational stratagems by saying that meeting the needs of employees is merely vocational training and that emphasis on basics of management is below the dignity of a science curriculum. Their curricula are often so crowded as to prevent breadth and flexibility for other needs.

Such arguments are, to our minds, narrow. University faculties should pay closer attention to what practicing wildlife management biologists actually do on a day-to-day basis. They should be aware of what agencies need and educate students to meet those needs, yet continue to stress science as fundamental in deciding policies and strategies in management.

Financial support of wildlife research in universities have by and large never been as great as for other fields of science. Wildlife faculty members are under constant pressure to obtain outside funding; efforts that often reduce the time they have available to spend with students. They are forever writing proposals to chalk up a publication record so as to gain tenure and position. When budgets and financial records of university departments and colleges are examined, almost without fail, wildlife programs have the lowest budgets for research and the ratio of "hard" to "soft" monies are smallest of any departmental research program.

Further, when funding is received from grants and contracts, it is often for research that may not be fully consistent with the primary focus of the department and/or not very relevant to the needs of wildlife resources, making wildlife faculty further detached from the real-world needs of employers, students and the resource.

Additionally, an area of growing concern is the long-held practice of university faculty and administrators to perpetuate and reinforce the value system that rewards those who devote their time and energy to research and deny those same rewards to those who devote a significant effort to education of students. In combination, these university infrastructure problems detract from an academic atmosphere that must encourage creative thinking, enthusiasm and new approaches to a diversified effort on behalf of wildlife resources.

The political evolution toward emphasis on land-use planning, environmental analysis, economic analysis, and a broadening of the emphasis on ''multiple use'' with its attendant interactions, has required the management biologist to deal with not only with basic biology but to broaden knowledge in management-related fields such as economics, politics and social concerns.

What, then, is appropriate training for today's wildlife manager? Our purpose is not to develop a model curriculum. In our view, there is none. We have not examined all of the offerings of universities, but our experience as employers of wildlife graduates and as members of review teams of wildlife education programs lead us to know that training in basic science and biology is not enough and that considerably more diversity and flexibility in educational programs for wildlife *managers* are needed. And, such training should concentrate on preparing most graduates toward the skills outlook, and attitudes needed by *managers* of natural resources and people.

What does this say for certification and accreditation programs for natural resources societies? Rigid certification requirements obviously are not compatible with flexibility and accommodation to the many directions that educational programs can provide. Certification and accreditation programs can promote professionalism but they can also constrain diversity. Not all students should follow the certification path.

Conservation organizations, government and non-government, must share responsibility for the dilemma of meshing educational offerings with their needs. As one university person succinctly expressed the problem, ''state and federal conservation agencies should be subjected to examination and accreditation for their uses of graduates and for their conservation strategies.'' The statement was obviously given ''tongue in cheek'' but it does point up that governmental agencies also may not be using graduates as effectively as they might.

Recommendations for Improving Educational Needs

Wildlife management is more than biology. More often than not, conservation problems are solved not by biological information or scientific truth alone, but by a combination of considerations that satisfy human interests. Thus education in the field should include cross-over curricular between departments. These might include courses and emphases in habitat-oriented departments such as forestry, range management, agriculture, water resources and marine science. Curricula should be flexible so that targets of students and needs of employers can be accommodated. Economics, political science, public policy, sociology, conflict resolution, law, administration and even cultural anthropology (especially in Third-World countries) are areas of increasing value in natural resources conservation.

Declare once and for all that a baccalaureate degree in wildlife is not the terminal degree for a wildlife biologist. Specialization should begin and need not end at the masters level. The undergraduate degree should include both ecological and conservation principles and studies of management policies and strategies with an interdisciplinary approach. The goal is a basic foundation for further honing with more specialized education.

Use some of the curricula to teach or demonstrate applications of science. This does not mean universities should offer vocational training; i.e., to have cookbook courses on every species of interest. It does mean to use departmental courses and case-history studies to examine and evaluate policies and strategies in conservation affairs. Integrating this information into a management philosophy or approach is what is needed. Such can be as much a part of the students' tools as ecological principles.

In upper-level and especially graduate-level programs, enlarge the scope of the students' world. Provincialism in subject and geography has kept many minds from addressing the larger issues that engage our world and threaten wildlife resources. Wildlife management is more than counting animals, measuring vegetation growth, and protecting scarce life. It addresses the welfare and necessities of human life. To ignore the human condition in conservation strategies is to fail.

We believe it important that university wildlife programs should have a complement of faculty members with experience in conservation agencies. Too often wildlife and fisheries departments are staffed with individuals with little or no experience in management. With new diplomas and fresh from their own research interests, they are long on science but lacking in the application of it.

A salting of faculties with at least some veterans of the management ''wars'' could go a long way toward influencing students as to what is necessary in successful management careers. Management agencies could make such faculty available on a rotating basis through exchange programs that could, simultaneously, expose young faculties to the day-to-day realities of life on the management line. Retired agency people would likewise provide needed real-life experiences to students who strive to understand what is expected of them when they graduate. Sabbaticals for faculty members to gain management experience rather than conduct research is another opportunity to broaden university education programs.

We believe wildlife science and its application in conservation are at a transition stage. Society has never been more informed or influential in conservation affairs. Conservation issues have never been more complex. Traditional biological education still must be the foundation science, but we must broaden our students and agency perspectives to meet societal demands and needs of wildlife resources. We in wildlife biology must be more than we are. It begins in university education.

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Educational Content of University Fish and Wildlife Programs Based on Expressed Needs of Federal and State Agency Employers

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Introduction

Although there is some disagreement (Oglesby and Kruger 1989, Peek 1989), wildlife and fisheries are considered to be professional degrees by most universities with a designated wildlife and fisheries program. Students enrolled in those programs also consider wildlife and fisheries to be professional degrees in that they expect to qualify for jobs upon graduation. Therefore, qualifications for entry level, professional positions are an important consideration in the development of wildlife and fisheries curricula. But a university education must do more than just provide a student with the technical qualifications needed for employment. A university education should provide a student with a general education in the humanities and basic sciences, bolster independence and creativity, and create a continuing desire for additional learning. This paper examines the expressed needs of employers of wildlife and fisheries graduates and attempts to provide guidance as to how universities can combine a broad general education with technical expertise in wildlife and fisheries.

The survey and information developed in this report were patterned after a similar effort recently completed by the University Program Standards Committee of the American Fisheries Society (Adelman et al. 1990). We followed the same general format and procedures. The overall goal of both surveys was to (1) identify the common knowledge shared by wildlife/fisheries professionals and required for entry-level positions, and (2) to use this information to suggest appropriate subject matter content for university fisheries and wildlife programs. This paper concentrates on wildlife.

Methods

Fifty state wildlife agency directors and 26 regional offices of the U.S. Fish and Wildlife Service, Soil Conservation Service, Bureau of Land Management, Corps of Engineers, U.S. Forest Service, Environmental Protection Agency. Animal Damage Control, and National Park Service were contacted by letter concerning the objectives of this study. Descriptions of all wildlife-related positions, from entry levels to the director, were requested. Two weeks after the original request was sent, a reminder letter was mailed to the nonrespondents.

A total of 576 position descriptions was received and evaluated to develop a list of skills, abilities, and knowledge needed to qualify for typical wildlife jobs. The position descriptions were grouped into 10 general and 4 specialty categories according to job title and duty similarities. The frequency of descriptions for each job category was tabulated, and each description was examined for wildlife biologist certification requirements. Position levels or steps, educational requirements, duties, knowledge/abilities, desired course work, and academic majors were recorded separately for each of the 14 general job categories. For each general position description, the duties and knowledge/abilities section was further divided into two categories, biological and managerial/communications/other.

Descriptions for each position were categorized according to seven minimal education requirement designations as follows: (1) high school diploma, (2) high school diploma plus experience, (3) B.S. degree, (4) B.S. degree plus experience, (5) M.S. degree, (6) M.S. degree plus experience and (7) Ph.D. degree. ''Experience'' involved at least two years of job-related experience; in the high school plus experience category, it also included college-level course work.

The 10 general position descriptions were further summarized into two lists; one for positions requiring a B.S. and one for positions requiring a M.S. degree. Desired courses and degree titles, if listed, were tabulated for all positions. For positions such as aid/laborer, conservation officer/agent and refuge/area manager, academic requirements varied greatly among the agencies sampled. Specifications ranged from high school graduation to some college experience, to an Associate Degree, or a Bachelor's degree. No detailed analysis of specifications for these positions was attempted because of inconsistencies among the agencies as to what constituted professional positions.

Results of Survey

Responses were received from 47 state agencies and from 22 federal agency offices, constituting a 91 percent response. An average of 10 (range 4–29) position descriptions was received from each state.

Job Descriptions and Titles

Of the 576 position descriptions in the 10 general and 4 specialty categories, biologists (n = 157) and technicians (n = 87) represented the largest portion of the position descriptions, 27 percent and 15 percent, respectively (Figure 1). The specialty positions had the fewest descriptions. There was a great variety in job titles for similar positions. For example, the general category of ''Biologist'' included titles of ''Wildlife biologist, Biologist, Wildlife Research Biologist, Wildlife Services Biologist,

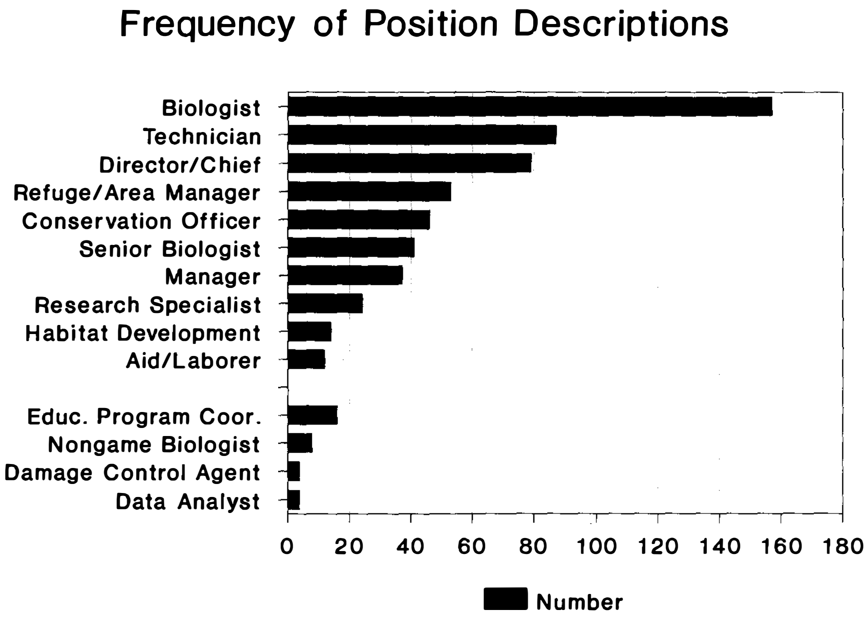

Figure 1. The frequency of descriptions for 10 general positions and four specialty positions.

Wildlife Zoologist, Game Biologist, Natural Resources Biologist, Biological Scientist, Game and Parks Biologist and Game Research Biologist."

Only 4 percent of the positions from responding state agencies listed wildlife biologist certification by the Wildlife Society as a requirement, and only 2 percent of the position descriptions encouraged certification. No federal positions listed certification as a requirement. Five positions from four states required the law enforcement positions or area managers to be commissioned law enforcement officers.

Sixty-eight positions (12 percent of the total) listed titles of "Fish and Wildlife." However, careful examination of most of these positions revealed they were usually for either one or the other, with only the title showing both. Technician positions most frequently required knowledge and skills in both wildlife and fisheries. Fisheries knowledge and skills for these positions included fisheries management techniques; sampling techniques such as electroshocking, netting, and trawling; fish propagation, cultivation, and harvesting techniques; general water quality techniques; and angler and creel survey techniques.

Many agencies used numerical designations (I, II, III) to differentiate between entry level and promotional or advanced entry level positions. Some used terms such as trainee, associate, assistant, senior or supervising. Most descriptions listed both management and research duties in the same position. However, some agencies did designate one or the other in the position title.

Academic/Educational Requirements

The majority of positions (61.3 percent) required a minimum of a B.S. degree (25.4 percent) or a B.S. degree plus experience (35.9 percent). High school diplomas and H.S. plus experience were required by 8.2 percent and 14.7 percent, respectively. M.S. degrees were required for only 15.3 percent of the positions. However, many of the "B.S. degree plus experience" positions recommended a M.S. degree. Only two descriptions (0.05 percent) listed a Ph.D. as the minimal education requirement.

Thirty-eight percent ($n=222$) of the descriptions lacked minimal educational requirements; of those, 48.6 percent ($n=108$) were federal positions. The educational requirements for each position were categorized according to the minimal requirement listed. Similar positions were found to have very different requirements. For example, requirements for technician positions varied from completion of an eighth grade education to having a Bachelor's degree with experience in wildlife-related areas.

Examination of all position descriptions for desired course work revealed that specific courses were seldom listed. Ninety-two percent ($n=529$) of the position descriptions did not list any specific courses. Listed courses ranged from the biological to physical sciences to communications and public relations courses (Table 1). Wildlife management, zoology and vertebrate biology were the most frequently listed courses, whereas communications and public relations courses were listed infrequently.

Academic majors also were examined for each position (Figure 2). Half of the position descriptions (49.7 percent) did not list any major. Of 650 total majors tabulated, wildlife sciences and biological sciences were the most frequent (66 percent); natural resources management and ecology accounted for 19 percent; and forestry, environmental science, and range management accounted for 8 percent.

Minimum Knowledge, Skills, Abilities and Duties

Entry-level wildlife positions, requiring Bachelor's or Master's degrees, stress communication, public relations and technical/mechanical abilities as much as biological knowledge (Tables 2 and 3). Expectations for M.S. degree level positions stressed increased knowledge levels and more program development, supervision and evaluation skills. An attempt was made top differentiate those skills and abilities which should be acquired in a university program from those which should be acquired in summer jobs, internships, special programs or by on-the-job training.

Discussion

The education of wildlife biologists in the United States is strongly influenced by the wildlife profession (Peek 1989). By surveying the major employers of wildlife and fisheries professionals, information is provided about the qualifications needed for entry into the profession. The position descriptions provide an indication of the skills, abilities and knowledge required for typical wildlife jobs.

The survey of position descriptions suggests that the primary emphasis in the wildlife profession continues to be on the Bachelor's degree, although there is some indication that this is shifting toward advanced degrees. The educational qualifications for entry-level biologist positions in most agencies specified a Bachelor's degree. However, many of these stated that job-related experience also was necessary. A Master's degree could be substituted for some, if not all, of the experience requirements. There is some indication that agencies routinely hire above the listed minimal education requirements, leading some wildlife professionals (*see* Peek 1989) to con-

Table 1. Desired courses listed in position descriptions.

Course	Number	Course	Number
Biological sciences		*Physical sciences*	
Wildlife management	38	Chemistry	26
Botany	33	Geology	23
Zoology	32	Organic chemistry	11
Vertebrate biology	30	*Communications/Others*	
Mammalogy	29	Statistics	19
Ornithology	30	Biometrics	17
Ichthyology	8	Mathematics/ algebra	7
Herpetology	5	Public speaking	5
Comparative anatomy	27	Technical writing	4
Soils	25	Computer science	4
Physiology	24	Journalism	3
Genetics	23	Economics	3
Population dynamics	23	English composition	2
Animal ecology	22	Criminal justice	2
Microbiology	21	Public relations	2
Entomology	20	Audio-visual	2
Public relations in natural resource management	18	Radio/TV	1
Wildlife diseases	18	Outdoor education	1
Wildlife law and policy	17	Photography	1
Silviculture	17	Personnel management	1
Embryology	17	Psychology	1
Wildlife conservation	16	Political science	1
Range ecology	16	Sociology	1
Plant taxonomy	11		
Plant ecology	7		
Invertebrate zoology	7		
Parasitology	7		
Forestry	6		
Behavior	5		
Limnology	4		
Park management	3		
Agronomy	2		
Animal husbandry	2		
Range management	1		
Cell biology	1		
Environmental law	1		
Population biology	1		
Habitat management	1		
Environmental science	1		

tend that the professional degree in the field is becoming the Master's degree, out of necessity and by default.

Placement surveys of wildlife and fisheries graduates, however, continue to reveal more entry-level positions are filled by graduates with Bachelor's than advanced

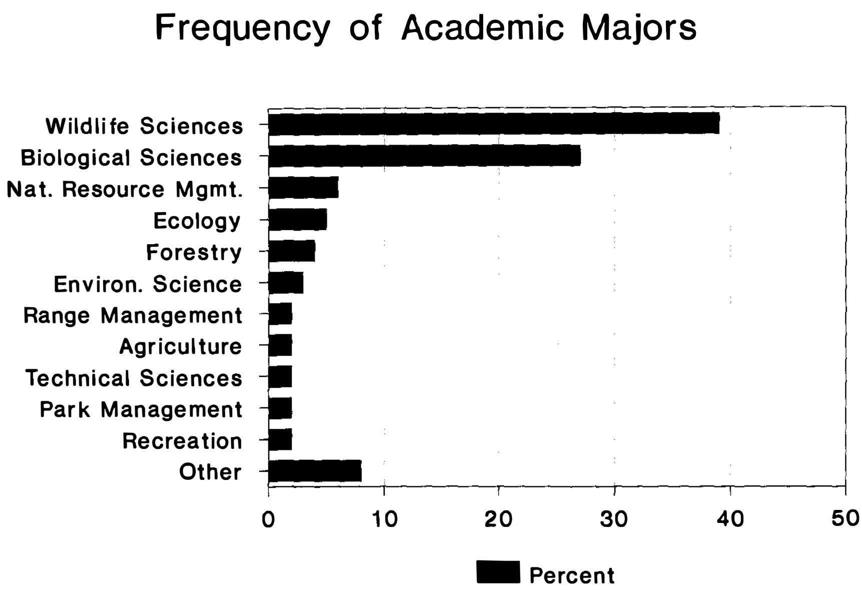

Figure 2. The frequency of academic majors requested by agencies.

Table 2. Duties, expected ofentry-level employees of state/federal natural resource agencies. Data were summarized from job descriptions specifying either a Bachelor's or Master's degree as the minimum educational requirement.

Bachelor's Degree

Biological/scientific:

- Survey and evaluate wildlife populations and habitats
- Assist in habitat restoration and management
- Develop and implement wildlife management plans
- Develop wildlife area objectives
- Perform various research investigations
- Provide recommendations on hunting seasons and bag limits
- Treat wildlife parasites
- Collect field or laboratory data
- Assist in compilation and tabulation of data
- Perform statistical analysis and interpretation of data
- Conduct literature reviews
- Assist in law enforcement

Managerial/communications/other:

- Monitor public use of land
- Use computers for data and word processing
- Provide technical advice and general information
- Prepare and maintain field, laboratory and managerial records
- Prepare technical and nontechnical reports
- Prepare budgets

(*continued*)

Table 2. (*continued*)

- Train, supervise, and evaluate staff
- Operate and maintain light to heavy equipment

Master's Degree

Biological/scientific:

- Plan, develop, implement and evaluate wildlife management objectives and programs
- Design habitat management plans
- Supervise and coordinate surveys of wildlife, habitats and hunters
- Develop and conduct wildlife research projects
- Formulate hunting regulations
- Provide input for environmental impact statements
- Prepare technical reports
- Analyze and interpret data
- Review research and survey proposals
- Assist in development of agency policy

Managerial/communications/other:

- Direct public-use programs
- Direct maintenance of facilities
- Develop budget and fiscal plans
- Direct public relations programs
- Train, supervise and evaluate staff
- Administer and monitor special permits
- Represent agency to public and private organizations
- Prepare and evaluate progress reports
- Use computers
- Write technical papers
- Attend and participate in professional conferences
- Oversee the use of heavy equipment
- Conduct literature reviews
- Enforce state and local laws
- Purchase and operate technical equipment

degrees, although employment success is higher for individuals with advanced degrees (Adelman 1987, Hodgdon 1988). Throughout this decade, wildlife employment opportunities have improved markedly for recipients of advanced degrees. However, the total pool of students in wildlife degree programs has been declining and fewer students are now pursuing graduate degrees (Hodgdon 1988). Therefore, although students with a Master's degree in wildlife may generally be more competent than those with a Bachelor's degree, it seems likely for the next several years that the largest portion of entry-level positions will continue to be filled by students with Bachelor's degrees.

The educational specifications required for entry-level biologists in the position descriptions were variable and often vague. None of the federal positions in our survey included degree-level requirements, and 38 percent of the total positions did not list minimal educational requirements, acceptable majors or degree titles. The focus for these positions was entirely on an individual's knowledge, skills and abil-

Table 3. Knowledge, abilities and skills expected of entry-level employees of state/federal natural resource agencies. Data were summarized from job descriptions specifying either a Bachelor's or Master's degree as the minimum educational requirement. Master's degree graduates would be expected to have increased knowledge and proficiency in the areas listed below. Skills that we believe are not appropriately offered in a university program are listed separately.

Biological/scientific:
- Wildlife biology/ecology to understand habitat requirements, life histories, and distribution of animal (mark/recapture, hunter and kill surveys)
- Wildlife management principles and procedures
- Population estimation and sampling techniques
- Species identification
- Methods of age and sex determination
- Habitat management and restoration techniques (range management, soil conservation, farming practices, forestry, plant and pest control)
- Wildlife diseases and parasites

Managerial/communications/other:
- Collection, tabulation and analysis of data
- Wildlife laws and regulations
- Public relations
- Working knowledge of computers
- Scientific literature searching
- Employee supervision
- Budget preparation and management
- Oral and written communication
- Socio-economics
- Map reading

Non-university
- First aid
- Firearm use and safety
- Hunting and trapping
- Rough carpentry
- Operation and general maintenance of vehicles, equipment and small tools

ities. Under these circumstances, students with advanced degrees would be expected to gain a decided advantage in the job market.

The job descriptions and expected skills and abilities for biologist positions in state and federal agencies are demanding. The expectations of state and federal agencies for entry-level wildlife professionals commonly include the following qualities: (1) understanding the fundamental biological sciences, emphasizing "whole animal biology" and ecology; (2) knowledge of fauna and flora, emphasizing wildlife populations and habitats; (3) understanding of conservation and management principles and practices; (4) knowledge of the scientific method, experimental design and sampling procedures; (5) familiarity with scientific literature and capability to retrieve scientific information; (6) computer literacy in word processing and analysis, management and summarization of data; (7) skills in critical and independent thinking, planning and problem solving; (8) skills in oral and written communication, public speaking and public relations; (9) management skills stressing employee supervision and budget preparation; (10) ability to operate and maintain equipment, scientific instruments and sampling gear in both field and laboratory; and (11) the ability and motivation to perform as a professional for the public, the resource and the agency.

These requirements are generally similar to those specified for fisheries positions (Adelman et al. 1990). The main differences are in specific knowledge or techniques related to fish or wildlife.

This list of state/federal agency employer expectations has not changed appreciably during the last decade. At the end of the last decade, Anderson (1982) surveyed resource agencies to assess and identify professional educational needs and opportunities, and his list of job descriptions and expectations is basically the same as that generated in this study. Careful evaluation of the individual positions descriptions, from which this general list of skills was produced, clearly reveals that the positions available and the expectations for entry-level professionals with state and federal agencies remain predominantly oriented to traditional wildlife areas, and the courses required, as stated, do the same. For example, in the materials we evaluated, nongame biologist positions accounted for only 1 percent of the position descriptions examined.

The wildlife profession seems to have been slow to adjust to the changing social values of the public, which have become more oriented toward the nonconsumptive uses of the resource (Wagner 1989). If the profession is to mature, then agencies will have to reprioritize and redefine their positions, to address the current emphases in resource management needs (e.g., social impact assessment and biological diversity) and new methodologies (e.g., geographic information systems and conservation genetics) for resource assessment. For wildlife professionals to enter the 21st century proactively, they must be trained to meet broader areas of expertise than in the past.

How, within a four-year degree program, are students prepared for entry-level employment? A diversity of opinions recently has been expressed about how best to structure academic programs and curricula to provide the background necessary for employment in fishery or wildlife positions. Although there has been no exact agreement, several consensus points have emerged.

Despite the lack of expressed demand by agencies, many universities have broadened their programs to encompass the full range of societal values and the new scientific/methodological dimensions. The catalyst for this change has resulted, in recent years, from a movement on many campuses toward a "core curriculum," emphasizing the humanities and basic sciences. Educators of wildlife professionals have embraced the movement to a broad-based education and begun to modify curricular expectations accordingly. This is consistent with the needs of employers. Indeed, the position descriptions specify the need for understanding human relationships and for communication skills.

It has become increasingly difficult to keep pace with curricula modernization through simple course material and traditional curricula activities. Increased technical course requirements, associated with mandated core curricular and certification requirements and coupled with the scientific information explosion, which has substantially increased the amount and breadth of scientific knowledge, have reduced the opportunity for students to explore fields outside the traditional disciplines. Requiring additional courses, and thereby reducing opportunties for students to direct thier own education, is not the answer.

Curriculum and educational programs must be adjusted to meet the full range of values that society assigns to wildlife resources, and they must incorporate the new developments and methodologies emerging from holistic resource management, conservation biology, restoration ecology and social-impact assessment. Our curricula must embrace more concern for threatened and endangered species, and for shrinking global biodiversity (Wagner 1989). The distinction between game and nongame species should be abandoned in favor of an integrated approach that treats both groups within the perspectives of an ecosystem (Crawford 1976).

In a four-year degree program, only an introduction to many of the topics can be achieved. However, that introduction should enable the student to qualify for entry-level employment, prepare the student for further study in an advanced degree, or through continuing education and on-the-job training. To achieve this, ways must be found to teach essential technical knowledge other than through traditional lecture/lab course offerings. Practical experience, through cooperative educational experiences, internships/externships, shortcourses and continuing education programs, should be expanded to facilitate the transfer of critical information to professionals in the field. Nielsen (1987) and Knuth (1987) provided excellent discussions of alternative approaches to develop needed skills in professional natural resource practitioners.

The information-transfer objective in our curricula should be shifted to emphasize processes rather than facts. The best way to serve students is by exposing them to a cadre of critical ecology, evolution and genetics, developed around a perspective of management and conservation theory, and coupled with the necessary skills to become better citizens of both the scientific and global communities. Students must be taught to think and read critically, and to employ a variety of interdisciplinary problem-solving approaches in their work.

Students also need guidance to take responsibility for their own education. The time demands of faculty associated with teaching, research and public service are such that they can't meet all of the educational needs of students. Student professional organizations must be strengthened to provide opportunities outside the normal classroom/lab/field trip environment for interaction among students with common interests. What better way is there for students to learn about working on team-oriented projects?

Employers also must take more responsibility for supporting education. State and federal agencies, for example, should establish hiring practices that support the educational programs they demand. Only specifying a degree in biology or zoology, with no content guidelines, produces many applicants for positions, but probably very few with an adequate background to assume management responsibilities. In 1981, the Professional Improvement Committee of the International Association of Fish and Wildlife Agencies drafted and approved a set of guidelines for resource agencies to use in describing and filling positions (Anderson 1982). In reviewing the position descriptions from almost a decade later, it is apparent that few, if any, of the recommendations have been followed.

Agencies have been leading advocates for a need to improve professionalism in the wildlife discipline. Why then is certification as a wildlife biologist not required for virtually any professional position? Is it because of a shortage of candidates who possess certification requirements, or is it because of a weakness in the qualifications expected? Or is it because agencies are concerned for legal reasons to apply these criteria? Certification has been in place since the 1970s, but its utility must be questioned if, after almost two decades, the major employers of fish and wildlife professionals fail to use it in minimum employment requirements. Perhaps we have used the wrong approach in designing certification requirements around specific courses in subject matter areas, as opposed to focusing on the minimum core of knowledge, skills, abilities and experiences required for a professional education.

The answers to the questions and dilemmas posed by this situation beg for a better dialogue among professionals associated with state and federal natural resource agencies and university educators. Along these lines, it is encouraging to see that some states are taking steps to encourage this communication. One of us (Adelman) is currently on sabbatical from his university to spend a year at the state natural resource agency. Such arrangements provide faculty direct exposure to agency problems and perspectives. But it is equally important to do the reverse as well. Universities should provide mechanisms and compensation for agency personnel to participate in their academic programs. Several mechanisms, ranging from adjunct or joint faculty appointments to assignment on curriculum committees, are available for universities to involve agency personnel in their instruction programs.

We believe the Bachelor's degree should and can be revived to represent a professional degree with adequate training for entry-level employment in natural resource fields. To achieve this will require changes in our educational approach as well as the expectations of employers. We believe that now is the time to act. University educators and natural resource professionals must work together to produce new and workable approaches to strengthening education in the training of professionals. The wildlife profession has the opportunity to take a leadership role in these efforts. To do so will require an open dialogue among university educators and wildlife professionals.

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Continuing Education for Biologists: The Forest Service Program

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Introduction

Conservation of fish, wildlife and overall biological diversity is carried out by thousands of individuals working in a wide variety of agencies, organizations and institutions. In the United States alone the number of people employed professionally in fisheries and wildlife management is probably in the tens of thousands. A large share of these professionals work for federal land and resource management agencies. States, counties and cities also employ many conservation professionals in programs of fisheries and wildlife management. And more than ever, natural resources professionals are being hired by private conservation organizations and their many local affiliates, as well as professional societies. Some employment opportunities are found with associations and political action groups, including congressional and legislative committees. And considerable numbers of conservation biologists find employment with private firms and academic institutions.

These thousands of resource management professionals perform many different functions in their work for species and ecosystem conservation. It is logical that the complexity of roles played by natural resources professionals should influence both the formal and informal education that is available to aspiring biologists. Yet formal education cannot prepare individuals for all employment situations. As Hester (1979) noted, undergraduate biological resource curricula tend to be restricted to scientific and technical courses. A result is that graduating students lack exposure to many of the disciplines that will figure prominently in their careers, such as public administration, environmental law, human psychology, legislative processes, planning, economics, technical and popular writing, policy formulation and political science.

A rigorous and well-rounded university education, including social, political and communication sciences and arts as well as the natural sciences, is essential for success as a professional biologist regardless of the roles played at any particular point in a career (Figure 1). Formal university education, however, cannot accomplish all the educational needs of professional biologists. It merely sets the stage for a lifetime pursuit of ever broader skills that is the continuing education process.

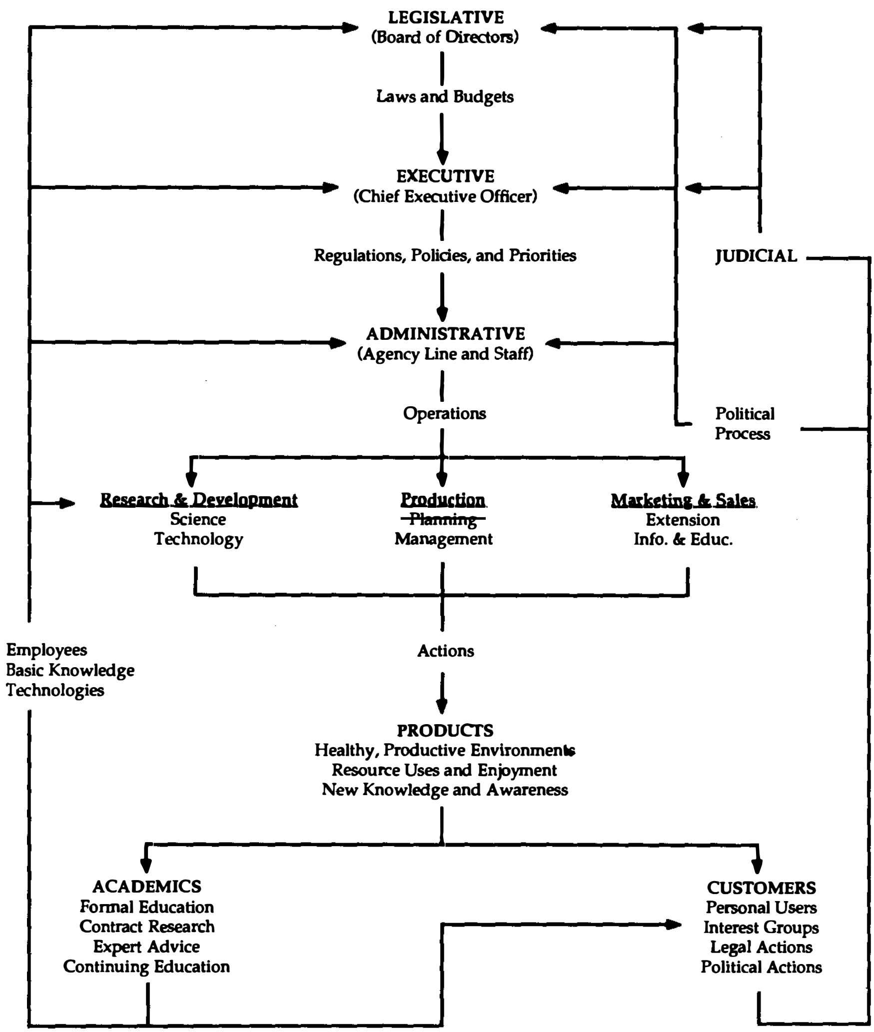

Figure 1. Schematic structure of fish and wildlife conservation if it were viewed as a business.

The importance of continuing education for natural resource managers is widely recognized (George et al. 1974, Graf 1976, Donaldson 1979, Hester 1979, Krausman 1979, Hampton and Stauffer 1981, Knox 1983). Whatever deficiencies remain at graduation must be corrected through on-the-job experience, technical training, and individual study through reading and coursework. Continuing education must maintain, expand and improve individual knowledge, skills, competencies and attitudes. In so doing, continuing education contributes to the advancement of individuals and the profession (Council on the Continuing Education Unit 1984).

Obviously a successful continuing education program must relate to the nature of the business or profession. Because fish and wildlife conservation is perceived differently by people of different backgrounds and preferences, we offer some basic premises about the nature of our business. These are of course, arguable, but are an important part of the rationale that underlies our continuing education efforts.

The Business of Conserving Fish and Wildlife Resources

The business of fish and wildlife conservation is protection, restoration and sustainable use of the full variety of fish and wildlife resources available to this and future generations. Conservation means that people are a part of nature, not apart from nature. Fish and wildlife management has a strong human dimension that is perhaps best captured by Aldo Leopold's (1948) view of conservation as man living in harmony with nature. Protection and restoration involve maintaining the physical and biological conditions that provide for long-term existence, functioning and adaptability of species, biological communities and the ecological processes through which they interact with one another and with their physical environments. Sustainable use may or may not mean consumption by humans; it can mean appreciative or vicarious uses as well. In any case, sustainability means that capital stocks and the evolutionary capabilities of populations and ecological processes must be maintained.

Success in conservation, like any business, requires acquisition and retention of customers. For fish and wildlife conservation this means (1) production and delivery of populations and species diversity, (2) under environmental conditions that people want and value, (3) at costs and accessibility they find reasonably attractive, (4) to a number of customers large enough to support the accomplishment of those goals (Levitt 1986). That may sound dreadfully businesslike to biologists, but it is, on the basis of historical experience, axiomatic. Conservation would not exist without a strong and vocal clientele willing to pay and carry out political battles for its products.

Conservation is carried out in a dynamic marketplace shaped by science, business, politics and faith. The products usually result from social forces such as customer preference, emotion, economics and tradition, interacting in complex ways among themselves and with biological knowledge and technical methods (Figure 1). The biological knowledge usually, but not always, establishes a foundation for reasonable solutions that can be molded by the other forces.

Professional biologists are faced with a real challenge in striving effectively to serve diverse customers in a multi-faceted marketplace. Their biological mission is to help shape and accomplish the aims of their employers relative to fish and wildlife productivity and diversity as those serve human needs such as agriculture, recreation, commerce or subsistence. Employers of biologists have different aims and strategies. Thus each biologist's role, whether scientist, educator, manager, policy maker, marketer, expert consultant, technician or advocate, will differ according to the aims of his or her employer. To remain technically competent, biologists must have access to state-of-the-art knowledge and skills to develop and accomplish management objectives for fish and wildlife. But to be truly effective, biologists must also know how their role fits with those of other employees in reaching an organization's goals.

Traditional Approaches to Continuing Education

The premise that conservation is a multi-faceted business shaped by complex forces implies that continuing education must expand from the traditional opportunities offered in the name of professional development. A common approach to continuing education is to bring professionals back to an academic setting to avail them of the knowledge of educators and scientists. Here they may attend "refresher" shortcourses on narrowly defined subjects relevant to the biological sciences, for example, population modeling or statistics for biologists. Or the purpose of the shortcourses may be to expose professionals to academic basics that they have not delved into since their college days. Typically, there is an emphasis on the skills and techniques aspects of wildlife, fish and habitat management—for example, the latest techniques in habitat manipulation or population estimation.

Professionals returning from such training sessions and shortcourses are often disappointed with the outcome. Common complaints are that the experience failed to strengthen their ability to solve complex real-world problems; that they had brought back little having practical or direct application in their work; and that the educators seemed out of touch with their needs. These results, though disappointing, should not be surprising given the one-way flow of knowledge that characterizes most undergraduate and graduate education and that has been extended, inappropriately, to continuing education.

Correction of this problem requires some restructuring of how we think about roles and career development opportunities. For example, there are many cases where biologists from management organizations return to universities for additional education, but relatively few cases where biologists from academia use a sabbatical to work for a resource management agency or political advocacy group. Given the value of hands-on experience in the educational process (Weiss 1984), we should expect only limited success in continuing education programs where the teachers lack the breadth of experience and accumulated practical knowledge of the students.

The most pressing needs for continuing education are revealed by examining the barriers that prevent professionals from being effective in the workplace. Such an assessment was made by M. Rupert Cutler (1982), reflecting on his years as Assistant Secretary for Natural Resources in the U.S. Department of Agriculture. He decried the inability of professional biologists to implement wildlife programs in a competitive bureaucracy, and cited these weaknesses: ". . . biologists are unwilling to take the ball and run . . . they are not equipped to lead, but only to respond . . . objective setting, decision-making and integrated planning appear foreign . . . students are trained to do animal research rather than habitat management . . . biologists have a reputation of being able to point out the problem, but lack the skills to help solve it in a manner that achieves the multiple objectives of preserving wildlife values while also attaining social needs . . . today's wildlife specialist should be educated, not trained."

We suggest that, most of all, wildlife and fisheries professionals need help to respond to the sweeping changes of how society views its biological resources and the demands it makes for their management. Herein lie the greatest needs for expanding and evolving professional competence. Today's biologists must have technical knowledge and skills to respond to current biological issues such as biological diversity, habitat fragmentation, population viability and evaluation of the cumulative effects of management. They must be sensitive to prevailing attitudes and social values that shape management of public resources. And they must have effective leadership and communications skills to develop sound programs to affect change.

The Forest Service is responding to these needs in a Continuing Education Program for Wildlife, Fisheries, and Related Disciplines. The goal of the program is to enhance the productivity and effectiveness of professionals whose work involves management of wildlife, fish and sensitive plant habitats. We will examine how established professionals acquire additional skills and knowledge to become effective leaders in integrated resources management.

The Forest Service Program

The Continuing Education Program for Wildlife, Fisheries, and Related Disciplines, initiated in 1987, is carried out in partnership with universities and other education institutions. At this time partners include Clemson University, Colorado State University, Northern Arizona University, Oregon State University, University of Idaho, Utah State University, Virginia Polytechnic Institute and State University, Yale University, the Environmental Law Institute and Bureau of Land Management (BLM) Phoenix Training Center. These institutions host graduate-level shortcourses that comprise the academic portion of our mid-career program. They may also utilize this coursework in the professional development programs of The Wildlife Society, American Fisheries Society and Society of American Foresters.

The Forest Service is assisted by the universities in curriculum development. Instructors for the shortcourses are carefully selected for their recognized leadership in the subject area and for their communications skills. They include university professors, Forest Service managers and researchers and specialists from other agencies and private organizations. The education experience is best where discussions and exchanges of knowledge are encouraged and where practical exercises are part of the program.

We have organized the Forest Service Program around three subject areas important to professional development. They are equally important so order of priority is not implied: (1) technical competencies; (2) leadership and organizational effectiveness; and (3) understanding of resource policies, economics and values.

The first area reflects the need for continual updating and refinement of the technical and scientific knowledge acquired during the undergraduate and graduate years. These needs are met in part by reading scientific journals and books. Many of our professionals lack easy access to scientific literature, and most have job demands that leave little time for reading. Shortcourses provide an intensive learning environment that is free from the normal distractions of the workplace, and where scientists may share new developments interactively with practitioners.

The second area, leadership and organizational effectiveness, reflects deficiencies that often remain from previous schooling and experience. Leadership and communications skills are critical to the individual's success within the organizational culture (Kennedy 1985). Regardless of the institution or agency context of employment, a professional biologist must accomplish results by getting others to take action or recognize the need for change. Every reader can probably recall a biologist who was a technical wizard but whose style so alienated colleagues that the technical expertise never was put to effective use. Continuing education can offer perspectives on how to exert leadership and be effective in many different settings. Our continuing education program provides skills and knowledge to help every professional become an effective agent for change.

The final area of competence for effectiveness is a working knowledge, if not mastery of, public policy, economics and human dimensions in fish and wildlife conservation. This is a universal weakness of professionals in conservation whose undergraduate and graduate education was narrowly focused in biology, ecology, botany or zoology. Similar weaknesses characterize many graduates of natural resources curricula in land grant agricultural universities (Lyons and Franklin 1987). Yet the values of biological resources, real or perceived, and the ability of professional biologists to make the disciplines of economics and policy work on behalf of those biological resources are probably more influential in actual conservation strategies than are technical issues that come out of the biological disciplines. In supporting this point, Lyons and Franklin (1987) note that, ''Resource policies and the processes by which they are formed determine how natural resources will be managed, who will manage them, and who will gain or lose when the policies are implemented. Policies set the criteria and standards which guide managers in fulfilling their professional and legal responsibilities.''

Shortcourses addressing these key subject areas, together with completion of individual projects, comprise the ''core curriculum'' of the continuing education program. Our goal is for all mid-career wildlife biologists, fisheries biologists, and botanists to complete the core curriculum as part of their professional development with the Forest Service.

The Core Curriculum

Currently, the core curriculum includes two-week shortcourses in wildlife habitat management; fish habitat management; leadership and communications; and resources policy, values, and economics.

Wildlife habitat management. Host institutions for this shortcourse include Utah State University, Northern Arizona University and Virginia Polytechnic Institute and State University. Objectives are to study habitat issues and concepts that shape national forest management at the national, regional and local levels; increase participants' knowledge and understanding of habitat concepts in light of current theory, technology and research findings; and apply new knowledge to situations and actual problems encountered in national forest management. Emphasis is on contemporary issues, including biological diversity, ecology and management of old-forest habitats, habitat fragmentation and population viability. Participants are exposed to concepts and technology needed to address these issues such as landscape ecology, geographic information systems, landscape simulation models, and biology of small populations.

Fish habitat management. This shortcourse is hosted by Colorado State University. Objectives are to acquire needed skills and knowledge to evaluate physical factors (including geomorphology and hydrology) affecting aquatic enhancement projects, and monitor effects of forest management on aquatic resources. Most mid-career professionals have either an aquatic or a terrestrial orientation and will complete either the fish habitat management or the wildlife habitat management course as part of their individual development. Some may complete both courses, because they have job responsibilities in both fisheries and wildlife.

Leadership and communication. This course is hosted by the University of Idaho and by Virginia Polytechnic Institute and State University. Objectives are to sensitize participants to leadership styles and to value systems of colleagues, the agency and publics; learn essential communications skills; practice negotiation techniques; and plan for personal and professional growth. Specific topics include problems solving styles and techniques, the decision-making process, understanding personality differences, group dynamics, team management, consensus building and personal effectiveness.

Resource policy, values and economics. This shortcourse, hosted by Yale University and Oregon State University, provides professionals with essential knowledge in public policy, economics and human dimensions in fish and wildlife conservation. Objectives are to understand the complex factors involved in policy development, strengthen knowledge of the role of economics in management of natural resources, and increase comprehension and appreciation of human value systems that underlie policy making and economics. Selected case studies emphasize the blending of social, economic and biological forces that enter into resolution of natural resources issues.

Other Courses

The core curriculum is supplemented by additional shortcourses offerings to increase effectiveness of practicing professionals. Specialists in various disciplines are encouraged to complete these as part of their individual development programs.

Managing forest structure and composition. This two-week course strives for a mix of participants including biologists, silviculturists and professionals from related disciplines. Together, participants explore opportunities and techniques for managing forest structure and composition to achieve compatible objectives for wildlife, fisheries, timber production and other uses. The course is hosted at three locations, each having a focus on the forest types within a broad geographic area. At Oregon State University, emphasis is on the Pacific northwestern forest types. Clemson University features forests of the eastern and southern U.S.; and forest of the Rocky Mountains, southwestern and intermountain regions are featured at Utah State University.

Endangered, threatened, and sensitive species management: The legal and administrative setting. This three-to-four day shortcourse, developed and hosted by the Environmental Law Institute of Washington, D.C. will be first offered in Spring 1990. This course responds to the needs of biologists and other professionals to understand and carry out legal requirements for threatened, endangered and sensitive species. Objectives are to increase understanding of legal processes, politics, economics, the media, and public attitudes as they relate to threatened, endangered, and sensitive species management. Participants develop skills to promote public involvement, build an administrative record, coordinate with other agencies on threatened, endangered and sensitive matters, and interact with lawyers.

Interagency shortcourse on biological diversity. This three-day shortcourse (with optional three-day fieldtrip) is sponsored jointly by the Bureau of Land Management, Forest Service, Environmental Protection Agency and U.S. Fish and Wildlife Service. The target audience includes mid and upper level managers in land and resource management agencies as well as the resources professionals who assist them in planning and implementing management programs. The objectives are to clarify the biodiversity issue for land and resource managers, increase understanding and appreciation of biological diversity and explore opportunities and strategies for conserving diversity throughout the public domain.

Roles for Universities, Agencies and Professional Societies

A successful continuing education program depends on an active, three-way partnership between employers, educators and professional societies. Our experience has shown that a laissez faire approach to continuing education does not work. There is certainly a marketplace with demand forces and supply factors, but the meeting of demand and supply for continuing education requires active management.

Empirical evidence supports this assertion. Professional societies involved in conservation of natural resources are now actively carrying out or developing continuing education programs complete with standards, record keeping, recognition and, in some cases, certification. Professional society programs recognize the need to develop and manage a set of courses and experiences that achieves specific goals for their members.

Roles of Professional Societies

A basic role of professional societies is to set standards that define competency, distinguish members, and ensure credibility. In the social fabric of any culture, professions have stature and credibility commensurate with their contributions and degree of rigor in their standards of professionalism.

For example, The Wildlife Society is the only professional body that can define qualifications and professional development standards for a practitioner of "wildlife biology" or "wildlife management" as distinct from other brands of biology and conservation specialties. A professional society that does not set and enforce such standards of competency and excellence will be viewed as an intellectual hobby or social club by society at large and by other professionals. If it sets standards too low, professional credibility will suffer. If it sets them too high, there will be too few adherents. Setting standards is difficult, contentious and divisive.

Once standards are set, such as was done in the certification and professional development programs of The Wildlife Society in the 1970s and 1980s, the society must actively manage a continuing education program for its members and interested professionals from related disciplines. Absent this service to members, employers who value professionally competent biologists must pursue such a program.

Roles of Agencies and Employers

Most professional fish and wildlife biologists are employed by state and federal agencies. Some work in the private sector. These employers have much to gain from better educated, more effective employees: efficiency, confidence in abilities, recognition as a leader in the field, and morale. Historically many agencies that employ biologists have been indifferent to continuing education. They have stressed in-house training, which is valuable for some aspects of the agency's mission, but also a recipe for severe inbreeding depression.

A first step for employers is to require a formal professional development plan (training plan, if you will) for each employee. The plan must blend individual needs with those of the agency. Progressive agencies striving for excellence and efficiency could devote 10–20 percent of an employee's time to professional development. Creative development planning can make much of this time immediately productive through practical, problem-solving-oriented courses or workshops.

A second step is support from all levels of administration in the agency. Professional development entails a financial commitment that will require executive level as well as supervisory level support. The USDA Forest Service, for example, funds continuing education programs in silviculture, recreation, and wildlife and fisheries habitat management at the highest administrative levels.

A third step is to conduct periodic job analyses to determine kinds of tasks people are doing and kinds of skills they need to maintain or develop. Where standard competencies can be identified, for example, effects analysis, these can become objectives for continuing education courses.

Finally, a crucial step is for agencies to join with professional societies and universities in developing and carrying out a continuing education program. The USDA Forest Service, for example, designates a member of its headquarters wildlife staff and a regional or forest level biologist to lead or work with university faculty and professional society representatives on committees that design and conduct shortcourses.

Roles of Universities

The third member of the continuing education triumvirate is universities. Universities have faculties with a wide range of expertise, and most professors are excellent teachers. They have the facilities, support services and, most essential, a free-thinking environment.

But continuing education is not just an extension of normal, subject-oriented academic courses where professors instruct students in a specific body of knowledge. Continuing education instruction is more problem or issue-oriented, often addresses far more complexity than traditional disciplinary courses and involves students who may know more about many aspects of the topic than the instructor. Many faculty lack extensive experience in dealing with complex resource management problems. Involvement with continuing education courses can provide a two-way flow of awareness and experience, thus benefiting faculty as well as student. The result can be improved understanding and better education at undergraduate and graduate levels.

Universities need to play an active role. It should include leadership on design, organization and conduct of seminars, symposia and shortcourses. This role cannot be taken lightly and will entail significant expenditure of faculty time in preparation and interaction with students. It will require commitment by deans and higher level administrators to broaden the educational mission of the university, giving credit to faculty for involvement in the program.

Summary

Continuing education is a phase in the development of professional biologists. It must address the needs of a wide variety of people involved in fish and wildlife conservation and it must be well-managed. Hit-or-miss will not work to reach the goals of technical, managerial and political excellence.

Subject matter should address the state-of-knowledge and technologies in scientific disciplines that comprise fish and wildlife biology as well as skills and knowledge needed to put technical expertise to use.

Management of a continuing education program depends on a three-part partnership between professional societies, employing agencies and universities.

Jack Ward Thomas (1985), past-president of The Wildlife Society, and eminent wildlife scientist, sums it up well (paraphrased): today's professional biologist must know how to integrate conservation into today's economy and be able to package and market biological initiatives as politically viable strategies. The effective biologist, in addition to biology, understands (1) economics and politics, (2) the role of economic and political considerations in decision making, (3) the nature of the economy as it affects the current situation and (4) the increasing expectations that people's assets produce revenues.

The business of fish and wildlife conservation is in competition with all other businesses for access to the great land and water resources of this nation. The ultimate goal of continuing education in fish and wildlife biology should be to enhance the competitiveness of biologists in that marketplace.

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Cooperative Wildlife Management: Implications for Wildlife Management Professionals

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Introduction

The professional ranks of wildlife management agencies of North America have traditionally been staffed almost exclusively by biologists. Indeed, other professionals have rarely been members of the wildlife management fraternity. In reality, one does not have to have a biology degree to get involved in wildlife management. The vast majority of hunters probably do not have such qualifications. However, for those that wish to enter wildlife management career paths, the Bachelor of Science (Biology) has generally been the minimum entry requirement.

In recent decades, this situation has slowly begun to change as the nature of wildlife management itself has changed. Wildlife management is an increasingly complex undertaking, involving an expanding range of issues beyond the realm of biology. This paper examines these trends with a view to identifying their implications for wildlife management professionals. It begins with a brief review of the history of wildlife management and the changes taking place within it today. The discussion then moves to a consideration of a new management paradigm, that of **cooperative wildlife management (CWM).** It is argued that this approach exemplifies the changes sweeping wildlife management, and that it will become an increasingly common way of doing business in the wildlife management field. In a third section, the implications this new approach has for wildlife professionals is discussed. In a concluding section, several comments are made regarding the means by which wildlife professionals can respond positively to the opportunities provided by these new developments.

Trends in Wildlife Management

Wildlife management has its roots in the mid-1800s with the writings of Henry David Thoreau and John James Audubon. These authors stressed the need to appreciate nature for its own sake and to act to protect it (Paehlke 1989). Later conservationists focussed on the need for greater efficiency in the use of natural resources generally. Authors such as George Perkins Marsh, John Muir and Aldo Leopold added a more ecological perspective to conservation, making it less anthropocentric in character (Paehlke 1989).

For the most part, wildlife management activities traditionally have been geared towards maintaining wildlife populations in such a way to suit the needs of hunters (Phillips 1934, Gottesman 1983, Mitchell 1986). Other resource user groups were rarely factored into management equations. This situation was fine for the late 1800s when wildlife populations were still generally healthy and had a great deal of relatively untouched wilderness in which to roam. Hunting pressure, though locally significant, was not sufficient to threaten entire wildlife populations. Nonconsumptive resource users were limited in number and had difficulty in gaining widespread access to the resource. Subsistence hunting, if it was considered at all, was not thought to be worthy of inclusion in management decision making (Eramus 1989).

This situation began to change in the early 1900s. Mid-western hunters harvesting birds for the restaurant markets of the eastern seaboard severely depleted several bird populations and hunted the passenger pigeon to extinction and the Eskimo curlew to near extinction (Hewitt 1916, Phillips 1934). The continuing westward expansion of settlements, hastened by the Great Depression, meant that the amount of untouched wilderness began to decline rapidly. Key wildlife habitat came under the plough, was destroyed by forestry and mining activities or was covered over with towns and cities while the popularization of the automobile meant that the general public gained far greater access to wildlife than ever before. During this same period, aboriginal groups became increasingly assertive in their demands that subsistence hunting considerations be addressed by governments. In short, the history of wildlife management in this century is characterized by increasing competition for resources in the face of dwindling resource supplies.

Generally speaking, government wildlife agencies were able to successfully balance these opposing trends with little interference or scrutiny from the general public. To the extent that governments bothered to discuss their programs with the public at large, the intent was usually to *inform* the public, rather than to listen to it (Glass 1979). However, beginning in the early sixties, public demands for greater input to government decision making began to escalate sharply. Citizen action groups, primarily involved in urban planning issues, refused to allow governments to unilaterally impose programs upon communities (Arnstein 1968). Human health concerns raised by authors such as Rachel Carson (1962) fueled the desire of interest groups and the public at large for greater government responsiveness and sensitivity to its concerns (Schnaiberg 1980). Processes such as environmental impact assessment (EIA) were designed to facilitate such input (FEARO 1979, Lewis 1985).

In tandem with these developments, the range of issues confronting wildlife agencies has expanded rapidly over the past 25 years. Activities such as EIA, virtually unknown in 1965, were drawing heavily upon government resources by 1975 (Berger 1977, Page 1986). Greater knowledge and understanding of toxics in the environment has created a whole new area of concern. Issues as diverse as acid rain, land-use planning, native land claims, and climate change have, at least in part, fallen to wildlife agencies to address.

Resources available to these agencies have grown considerably in past decades. Nonetheless, environmental agencies are under pressure to respond to public demands for access to the decision-making process while at the same time being asked to do more with the same or slightly higher levels of resources. If this trend continues, governments will have an increasingly difficult time in coping with these demands. They will be forced to share workloads and decision-making responsibilities with the public if wildlife management is to be carried out effectively. It is in this context that **cooperative wildlife management** may well be the way of the future.

Cooperative Wildlife Management

Cooperative wildlife management seeks to unite government wildlife management systems with regional or local indigenous systems to form a third management paradigm consisting of elements of both. It involves the joint development and implementation of management frameworks which bring wildlife agencies and user groups together in a effort to ensure the long-term viability of wildlife resources while addressing the resource needs of user groups. It specifies the rights and obligations of the participants with respect to the resource. Finally, it clearly delineates the ways and means to be used in jointly collecting, disseminating and analyzing information about particular wildlife resources and the uses they can sustain.

To date, specific CWM agreements (CWMAs) have generally involved aboriginal groups and government wildlife agencies. This is primarily due to the special legal and socio-cultural ties aboriginal peoples have with respect to wildlife (Elliot 1985, Cohen 1986). However, CWM is not an alternate vehicle for the negotiation of definition of aboriginal or treaty rights. Rather, it is a mechanism for enabling these rights to be exercised in a fashion which ensures conservation of the resource and acknowledges the needs of other resource users. As such, it does not involve the transfer of rights or authority in either direction between governments and user groups.

The suitability of the CWM approach is not confined to situations involving aboriginal groups. On the contrary, any user group could logically enter into CWM arrangements with government. On a broader level, it could be argued that many wildlife agencies are already involved in CWM initiatives of one kind or another. For example, the North American Waterfowl Management Plan relies fundamentally upon cooperative partnerships for its success. While such initiatives are broad-ranging programs rather than specific CWM agreements, they are premised upon the same spirit of cooperation and draw upon similar resources. Thus, the CWM approach has a broad-based applicability and should not be though of exclusively as a vehicle for dealing with aboriginal issues. Notwithstanding the general utility of CWM, most formal CWMAs (Quebec 1976, DIAND 1984, USFWS 1985, Cohen 1986, Inuvialuit Game Council 1988) concluded to date have involved aboriginal groups. It is upon the lessons learned from these agreements that the remainder of this paper focuses.

These agreements have several common characteristics. First, they generally feature the establishment of joint management boards or committees comprised of an equal number of government and aboriginal representatives. Non-governmental organizations are not formally represented in the agreements. The management bodies are all *advisory* in nature in that the government retains ultimate decision-making authority. However, in practice, it seems that many CWMAs establish *de facto* decision-making bodies as the relevant government minister must provide written reasons for disagreeing with any recommendations forwarded to them. This requirement appears to make it clear that governments will ignore or override recommendations in only the most unusual of circumstances.

CWMAs generally pertain to the full range of wildlife management activities, from the setting of specific harvest quotas for individual species and regions through to the development of broad-based management plans and related legislation and policies. Habitat protection concerns are also within the general purview of CWM. The management bodies tend to have responsibility for identifying and/or conducting needed research. Finally, the agreements usually specify the means by which management decisions will be enforced and the groups to which they apply.

Several conditions must exist in order for CWMAs to be successful. First, government must retain ultimate management authority over wildlife resources. While some groups, most notably aboriginal resource users have special rights meriting preferential access to wildlife, the various interests of society as a whole must always be looked to. Indeed, all segments of society have certain rights to the natural resources of the nation. Only governments, with their mandate and legal responsibility to pass laws affecting all citizens, are in a position to adequately balance the competing interests of all user groups (Dawson 1970). Without ultimate government authority, regionally-based CWMAs would devolve into a motley array of interest groups competing for access to resources.

That being said, a government willingness to *share power* is critical to the success of CWM. Government retention of decision-making authority does not mean that government makes all management decisions. On the contrary, CWM involves the development of *joint* decisions supported by all parties. Consequently, while ultimate government accountability is maintained, the exercise of power is shared. More importantly, all parties have a central role in the information gathering and evaluation required to make decisions. Only when user groups have such direct access to the decision making process and in fact become part of the process, will CWM work.

Power sharing of the nature contemplated in CWM initiatives is not easily accomplished. User groups, particularly aboriginals, have little experience with it because they have never had any formal power to to share (Eramus 1989). Power sharing does not come naturally to governments generally and civil servants in particular. Three primary reasons for this are apparent. First, wildlife management is often characterized as a highly complex undertaking requiring detailed scientific knowledge and considerable experience in observing animals in remote, inaccesible and inhospitable locales. The public does not possess such expertise and cannot, therefore, adequately contribute to management decisions.

Second, government agencies have never had any reason to want to share power and have, therefore, rarely made efforts to do so (Usher 1986).

Third, governments have generally not been keen on sharing power with aboriginals in any context. This may in part be due to a sense that aboriginal concerns are not of sufficient importance to merit special considerations. Although this feeling may be less common in northern Canada following land claim settlements, it appears to be present in other parts of Canada and the United States. Further, it seems that government agencies generally do not trust aboriginals to manage in the best interests of the resource. This lack of trust may be due in part, to somewhat racist doubts about the management abilities of aboriginal groups. However, a much broader range of barriers to trust development have plagued relations with aboriginals in the wildlife area. Perhaps most importantly, there are not yet many successful precedents for such relationships upon which to draw. Aboriginals and governments simply have not worked together in wildlife management. Trust is difficult to engender in the absence of familiarity with the people and institutions involved in management issues. Consequently, a vicious circle in which governments and aboriginals do not work together because they do not trust each other, and do not trust each other because they have no mutual experience to build upon, is established. Where this circle occurs, it must be broken if CWM is to succeed.

Several steps are essential to breaking this cycle. First, significant attitude shifts are required of both wildlife agencies and user groups. Most importantly, they must recognize their *mutual interest* in wildlife and the need to abandon adversarial, confrontationist positions regarding its management (Clad 1985, Blanchard 1987, Osherenko 1988). Participants in CWM must understand that they *need* each other's assistance in maximizing the success of wildlife conservation efforts. In this context, government agencies must appreciate that CWM is not simply an alternate method of getting aboriginals to comply with their regulations. For their part, aboriginal user groups must realize that they cannot affect the behavior of non-aboriginal users within or beyond their territory without the cooperation of government.

These attitude shifts will not occur overnight. In order to encourage their development, it is essential that both parties learn more about each other's management systems. Aboriginal resource users rarely have a clear understanding of the institutional structures and operating procedures of management agencies. From the government perspective, knowledge of indigenous management systems is virtually nonexistent.

Central to learning about each other's systems is the sharing of information. Information is the fuel that runs the wildlife management machinery and control of the fuel equals control of the machinery. Therefore, unless information is shared, CWM cannot operate jointly.

This information sharing involves more than simply passing tomes of biological data over to aboriginal user groups or having aboriginal elders tell government officials various hunting stories illustrating traditional values. The biological information upon which decisions are based must be jointly collected and evaluated if it is to be trusted by both sides (Busiahn 1989). Equally important, information must be easily accessible to members of the wildlife user communities.

Finally, and most importantly, government agencies and aboriginal groups must negotiate CWMAs which meet the needs of both parties. This is not an easy task. Negotiations can be quite protracted and difficult because both parties have so much at stake. They are generally highly complex undertakings and usually bring into play a far greater range of factors than is normally addressed by wildlife managers. In the following section, these factors and the demands they are likely to place on wildlife management professionals are considered.

Implications of CWM for Wildlife Management Professionals

The single most important implication of CWM is that it obliges wildlife managers to deal more directly and more frequently with the public generally and with user groups specifically. Wildlife management becomes a fundamentally people-oriented exercise rather than a predominantly biology-based undertaking.

This situation is well evidenced by the complexity of the negotiations which usually lead to the establishment of CWMAs. Negotiators of these agreements must possess a clear understanding of wildlife management theory and practice if they are to be effective. Equally essential however, is a solid grasp of negotiating skills and tactics, as negotiations can be emotional and hard-fought affairs. In this climate, poor negotiators are unlikely to be effective in defending the interests of their agencies. This is particularly true in light of the fact that many aboriginal groups have considerable negotiating experience and are fully capable of taking advantage of poor government negotiating tactics.

Although such negotiating skills can be acquired through experience, wildlife managers generally do not obtain them as part of their regular training. Consequently, negotiations are often conducted using a lead negotiator, often a lawyer, supported by wildlife experts. Wildlife managers are, as a result, often marginalized in a process which is directly related to their mandate and expertise. This difficulty could, conceivably, be overcome if CWM negotiations typically focussed primarily on biological management issues. However, this is not the case.

The negotiation and subsequent implementation of CWMAs introduces an array of issues which extend far beyond the realm of biology. Chief among these issues are the legal parameters which circumscribe the agreements. The law prevents full, formal delegation of ministerial decision-making authority to CWMA bodies, thereby placing an initial boundry around the agreement being negotiated (Dawson 1970). Further, ministers are legally bound to manage resources for the good of all society. Yet, at the same time, the courts have recognized the continued existence of Indian treaty rights and, in several instances, have ordered wildlife agencies to provide aboriginal user groups with a direct role in management decision making (Cohen 1986, GLIFWC undated). In some cases, the order has extended to issues of resource allocation, stipulating that Indians must receive a certain percentage of the harvest. In these instances, the courts have also directed that any CWMAs produced must be vetted by the courts prior to their implementation (Cohen 1986). Thus, wildlife managers are forced to deal directly with a variety of legal issues if they are to maintain control over the management process.

Political considerations also come to the fore in CWM situations. Any situation in which special wildlife harvesting rights are formalized for one group, usually aboriginals, will almost always be perceived by other groups as a diminishment of their own rights (Brynaert 1982, Indian Fishing Advisory Committee Report 1988, Driben 1987). The immediate reaction of these groups is usually to contact politicians and members of the media to express their views to them directly. Wildlife management becomes highly politicized as a result, and politicians often become directly involved in management activities. Political factors become key elements of wildlife management and the importance of biology as a primary decision-making factor is further diluted as a result.

In this atmosphere, user groups also become quite politicized. These groups often develop a multi-faceted agenda upon which wildlife may not be the top priority. Linkages to other issues completely beyond the control of wildlife agencies are often made, creating further difficulties for wildlife managers.

Socio-cultural differences also enter into the picture in agreements involving aboriginals (Feit 1988). The nature of these differences is beyond the scope of this paper to describe. However, they are important to CWM as they affect communication patterns, understanding of issues, decision-making priorities and general approaches to wildlife management (Maddock 1980, Spradley 1979). Failure to understand these influences will exacerbate the difficulties wildlife managers face in dealing with aboriginal groups.

The public and political interest in CWM, combined with its socio-cultural dimensions, necessitates the production and dissemination of information in a form that is easily understood and digested by the non-expert. The frequently turgid, number-filled style favored by many wildlife biologists will not be acceptable to this audience.

Wildlife managers will be required to collect and analyze information provided to them by user groups. Much of this information will be delivered orally and is unlikely to be organized in a fashion familiar to government decision-making frameworks.

Consequently, a variety of communication and analysis skills will be required to integrate and understand it.

Conclusions

The preceding pages have argued that wildlife managers of the future will face an ever-increasing range of issues that are beyond the scope of traditional wildlife management. Although legal, political and social concerns have been dealt with by wildlife managers for some time, these factors will feature more prominently in future decision making, while more management agreements and programs will be established through a process of direct negotiation with wildlife user groups. To date, this trend is best exemplified by the development of cooperative wildlife management agreements in several North American jurisdictions.

The role of biology within this new management milieu could well be diminished by comparison with its historic status in wildlife management. Some may argue that this situation has already developed and that today's wildlife management features far too much policy and politics and far too little good science and research. Whether this is true or not, if the analysis presented in this paper is correct, the trend toward such a situation is clearly well underway.

Wildlife professionals can deal with this trend and its implications in one of two ways. First, some may simply accept these developments as inevitable while wringing their hands in despair and lamenting the demise of biology as a key ingredient in wildlife management decision making. At the management level, this attitude may promote a focus upon brokerage decision making and broad policy questions in favor of potentially less politically saleable decisions based purely on biological factors. More generally, this response often involves a retreat into the less public areas of wildlife research in an effort to avoid "non-scientific" wildlife issues. It may also lead to the development of a perception amongst rank-and-file wildlife professionals that ultimate decision-making authority is in the hands of non-biologists who know little or nothing about wildlife. Individuals in this situation often feel helpless and unable to effect change. They simply shake their heads and pine for the so-called "good old days" when the biological needs of animals appeared to be at the forefront.

Alternatively, there are those who espouse a more positive and opportunistic approach. They argue that wildlife biology, though an inexact science subject to error as all science is, must be the central tenet of all wildlife management decisions. It follows from this principle that unless the biology of the resource is well understood and is foremost in the minds of wildlife managers, any decisions made with respect to the management of the resource must be premised upon fundamentally unstable footings. Wildlife management that treats biological data as information of secondary importance will soon lead to crisis situations in which there is very little resource left to manage. From this perspective, the appropriate approach is to deal with issues in the new, more stakeholder oriented way, but to keep biology of the heart of decision making.

The challenge facing supporters of this more opportunistic argument is to identify means for translating these feelings into effective actions designed to ensure that wildlife management retains its focus on biological imperatives. To simply urge wildlife managers to return to their roots to focus more on science while ignoring or downplaying policy and political issues is somewhat naive and is unlikely to achieve constructive, positive results. The socio-political influences described in this paper are not going to disappear. Therefore, wildlife professionals, if they are to be successful in maintaining and/or restoring the centrality of wildlife biology to decision making, thereby retaining control of their own management processes, must adapt to these current realities.

The wildlife professionals of the nineties and the next century must be well versed in legal matters affecting wildlife. They must understand and possess negotiation skills and tactics and must be able to use them effectively. A basic understanding of the socio-cultural characteristics of their user group constituents is equally necessary. Communication skills, both oral and written, will be increasingly important as governments are forced to share information with their publics on a more regular and comprehensive basis and as rapid information exchange technology continues to evolve. Finally, they will have to become comfortable with decision-making processes in which power is shared with wildlife users and the group replaces the senior official as the decision-making locus.

Many wildlife agencies have dealt successfully with a wide range of complex and sensitive issues which draw upon knowledge and skills of this nature. Consequently, a great many wildlife professionals have already developed some or all of these skills. However, these skills are acquired primarily through experience and generally reside with a relatively small group of individuals within wildlife agencies. They are not acquired as a matter of routine by wildlife professionals at all stages of the management process.

In the short term, this need not be a problem as there are plenty of experienced individuals still active in wildlife agencies who are capable of addressing the issues arising from CWM and similar initiatives. However, if, as is suggested in this paper, the trend toward CWM and greater public involvement in wildlife management generally, continues to accelerate, there will simply not be enough "old hands" to go around. Professionals will not always have the luxury of learning about legal, political or social aspects of wildlife management from their superiors. They will need to possess these skills from the outset.

This conclusion has significant implications for the educational institutions currently producing the wildlife professionals of tomorrow. While they must retain a central focus upon wildlife biology, exposure to the more general aspects of wildlife management is crucial. All too often, the social sciences aspects of wildlife management are ignored or given short shift by universities and colleges. Arts electives which might be expected to address these issues are still commonly perceived as "Basketweaving 101" courses to be taken to fill out degree requirements while boosting one's grade point average.

This situation must change if wildlife professionals are to operate effectively in the management context described above. Courses designed to teach these skills must become integral components of wildlife management curricula. They must be taught in ways specifically tailored to suit wildlife professionals, not as general electives of broad-based appeal but limited utility. Ideally, these courses should be taught by members of the wildlife fraternity.

The acknowledgement of the importance of issues beyond the realm of biology does not imply that wildlife professionals should abandon their roots and ignore the basic scientific principles of wildlife management. On the contrary, these principles must if anything, be emphasized more strongly in day to day management activities.

However, the most effective way to do so is to acquire the broader knowledge and skills required to deal with the socio-political influences affecting wildlife management today. This adaptive response to current trends is simply good management and is the best approach for the conservation of wildlife resources.

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Have The Wildlife Society's Publications Kept Pace with the Profession?

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Introduction

Introspective examinations are good for the soul. This applies to both the individual and the profession. This session is one of those benchmark occasions where we, "the wildlife profession," have had the opportunity to assess and discuss its status and progress. Today we have addressed the status of professionalism from several crucial perspectives: changing philosophical needs for university-related educational programs (Teer et al. 1990); the content of university training programs based on published entry-level resource agency job descriptions (Schmidly et al. 1990); successful strategies for continuing education in resource agencies (Salwasser et al. 1990); and the need for a new paradigm, cooperative wildlife management, in the future (Swerdfager 1990). But introspection is nothing new to the wildlife profession.

Such contemplative examinations of our profession may be found in the *Journal of Wildlife Management* (JWM) beginning with the earliest volumes (Bennitt et al. 1937, Leopold 1940, 1942) and continuing to the recent series of thoughtful essays by Capen, Teer, Edwards, Gavin, Bolen, Wagner, and Peek in the fall issue of Volume 17 of the *Wildlife Society Bulletin* (WSB). Certainly others have provided equally important contributions; witness the significant historical perspectives provided in the 50-year history number of the WSB (Volume 15), the discussions on management and scientific methodologies and approaches (Graul et al. 1976, Kadlec 1978, Romesburg 1981, Bailey 1982, McNab 1983), and several exchanges on professionalism and education (Crawford 1976, Eastmond and Kadlec 1977, and Thomas 1986 to name but just a few examples).

The 52-year history of The Wildlife Society (TWS) has spanned a period of significant changes in the status of wildlife resources as well as changes in wildlife and environmentally-related public (national and international) policies. We argue that wildlife professionals must be responsive to both resource needs (Peek 1986) and changing public values (Wagner 1989) with respect to wildlife resources. One way to measure responsiveness, to both changes in resource needs and public values, lies with a profession's publications. McDonald (1987), in listing the objectives of TWS, has noted that although publications are not explicitly mentioned in the current objectives, "it goes without saying that we, as scientists and managers, will publish." The TWS Code of Ethics for Certified Wildlife Biologists does indeed note that Certified Wildlife Biologists will ". . . disseminate information to promote understanding of, and appreciation for, values of wildlife and their habitat. They will strive to increase knowledge and skills to advance the practice of wildlife management."

The most visible evidence of our profession's priorities lies with the regular publications of TWS. The three serial publications of TWS are the *Journal of Wildlife*

Management, Wildlife Monographs, and *Wildlife Society Bulletin*. The JWM, first published in 1937, is the world's major source of wildlife management and research knowledge (TWS 1989). Wildlife Monographs, initiated in 1958, typically includes technical papers too long to be published in the JWM (TWS 1989). And the WSB, began in 1973, publishes original papers relating to wildlife management, conservation law enforcement, conservation education, economics, administration, philosophy, ethics and contemporary problems.

The purpose of this paper is to determine the relationships between subject matter of articles appearing in the JWM, WM and WSB and important public value changes and scientific "advances" in conservation paradigms. To date, several limited subject matter reviews of TWS publications have been published (Crawford 1976, Kadlec 1978, Adams and Thomas 1986, Hickey et al. 1987, Adams 1989, Capen 1989, Edwards 1989, Wagner 1989). These reviews have generally covered only part of TWS publications, or encompassed a single emphasis area, or represented but isolated sets of years. In no cases have the subject matter reviews attempted to correlate the entire spectrum of TWS publications, changing subject matter and changes in the public and scientific methodologies.

Methods

All numbers of the JWM, WM, and WSB were evaluated from the inception of each publication (JWM—1937–1989, WM—1958–1989, and WSB—1973–1989). These TWS serials are the only publications generally available to libraries and nonmember organizations. All articles were evaluated by the authors to ensure standard responses. Articles were classified by subject at three levels (27 animal species specific subjects, 10 functional topics and game versus nongame—Table 1). Each article received but one score in each subject level or category. In some cases an article did not receive a score by animal subject matter or game versus nongame designation if, for instance, the article did not use animal examples (e.g., an evaluation of a population estimation procedure). In some multiple species papers we arbitrarily assigned the species-specific subject to the first named species. In all instances an article received a functional topic designation. Articles that were primarily editorial communications, notices of meetings, corrections, etc. were excluded from this analysis. Data from the "relatively new" WM and WSB were combined with JWM data and lumped by 5-year intervals. For purposes of this paper only data on rabbit/hare, carnivore, Artiodactyla, grouse, pheasant/quail, turkey, dove, waterfowl, fish, endangered species, conservation education/human dimensions, game and nongame are reported.

The chronological designation of public value changes and significant scientific advances in conservation paradigms were derived partially after Hickey (1974), Kellert and Westervelt (1981), Capen (1989), Wagner (1989) and our own personal experiences (Table 2). Although the list is not exhaustive, we believe that these events likely are the kinds of changes that could be expected to have an impact on the literature of our profession.

Results

The analysis included 5,631 articles in 53 volumes of the JWM, 106 WM, and

Table 1. Subject area topics.

Species subject	Functional group	Species group
Rabbits/Hares	Habitat	Game
Chiroptera	Physiology/Nutrition	Nongame
Beavers	Wildlife damage	
Raccoons	Management/techniques	
Squirrels	Behavior	
Cats	Endangered species	
Other carnivores	Conservation education	
Marine Mammals	Literature	
Deer	Professional/Training	
Other Artiodactyla	Law enforcement	
Perissodactyla		
Primates		
Other mammals		
Grouse		
Pheasant/Quail		
Turkeys		
Doves		
Ducks		
Geese		
Cranes/Rails		
Shorebirds		
Seabirds		
Raptors		
Blackbirds		
Other birds		
Amphibian/Reptiles		
Fish		

1,022 articles in 17 volumes of WSB (did not include the Winter 1989 number which had not arrived at the time of this analysis) for a total of 6,759 articles. Change in percent of total articles by 5-year classes for turkey, dove, rabbit/hare, and conservation education/human dimensions represent subjects whose respective contributions have been minimal and, in the case of turkey and dove, have exhibited little variation

Table 2. Important public and scientific milestones affecting the wildlife profession.

Year	Milestone
1937	Formation of The Wildlife Society
1942	First experimental use of DDT in U.S.
1958	MacArthur's warbler community study
1962	*Silent Spring* (Rachel Carson)
1966	Endangered Species Preservation Act
1973	Convention on International Trade in Endangered Species of Wild Fauna and Flora
1975	*Sociobiology* (E. O. Wilson)
1984	*Fragmented Forest* (Larry Harris)
1987	Society for Conservation Biology

from 1937 to the present (Figure 1). The rabbit/hare category shows a relatively low level of representation with a perceptible long term decline. Our subject-based examination (Figure 1) documents, as well, the long-term minimal representation of conservation education/human dimensions. The latter category was entirely absent in the mid-1960s despite the changing public values associated with the publication of Rachel Carson's (1962) significant book, *Silent Spring*, and passage of the Endangered Species Preservation Act of 1966.

Subject matter contributions for pheasant and grouse categories each showed a long term decline with a noticeable peak of interest (Figure 2). The early peak for pheasants corresponds with the early identified need to have something to shoot (Leopold 1940, Robinson and Bolen 1984). The grouse peak in the 1960s reflects the contributions associated with the 1963 Grouse Symposium published in the JWM. In contrast, the carnivore category (Figure 2), exhibits a relatively recent increase which may represent a change in their legal status to game in some states, mounting animal damage concerns, and also appears to coincide with the 1966 Endangered Species Preservation Act and the theoretical contributions associated with ethology and newly emerged orientation represented by E. O. Wilson's (1975), *Sociobiology*.

Our analysis documented the beginning and the end of two subject matter areas in the course of the 52-year history of TWS. Figure 3 depicts the demise of fish papers, which had been historically associated with TWS publications. In fact, the last fish publication by TWS was the monograph by Stauffer et al. (1976). In contrast, the endangered species category emerges only after official designation by the Endangered Species Preservation Act of 1966. Although work had been published on known rare species before this time, the change in percent of total articles, albeit small, arguably shows some responsiveness to societal needs. Figure 3 also portrays

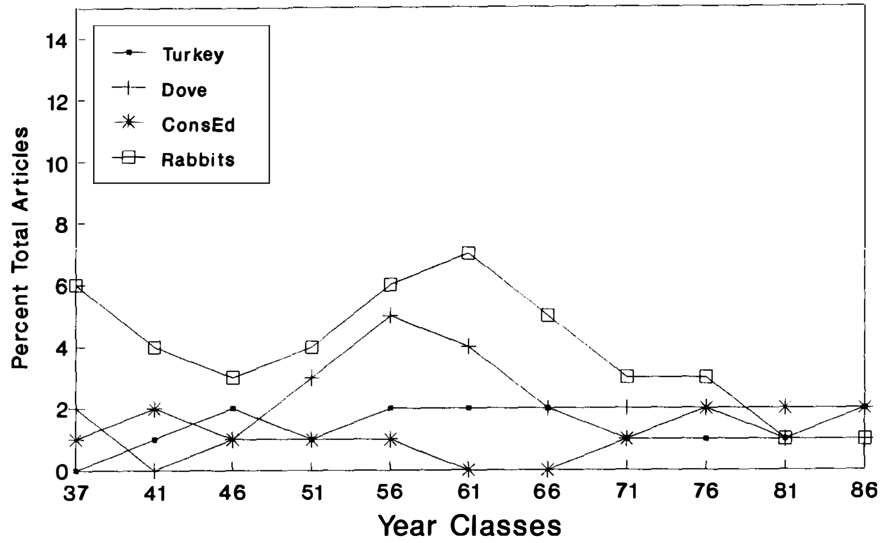

Figure 1. Percentage change in total TWS publication articles for turkey (wild turkey), dove (all Columbiforms), rabbit/hare and conservation education subject categories, 1937–1989.

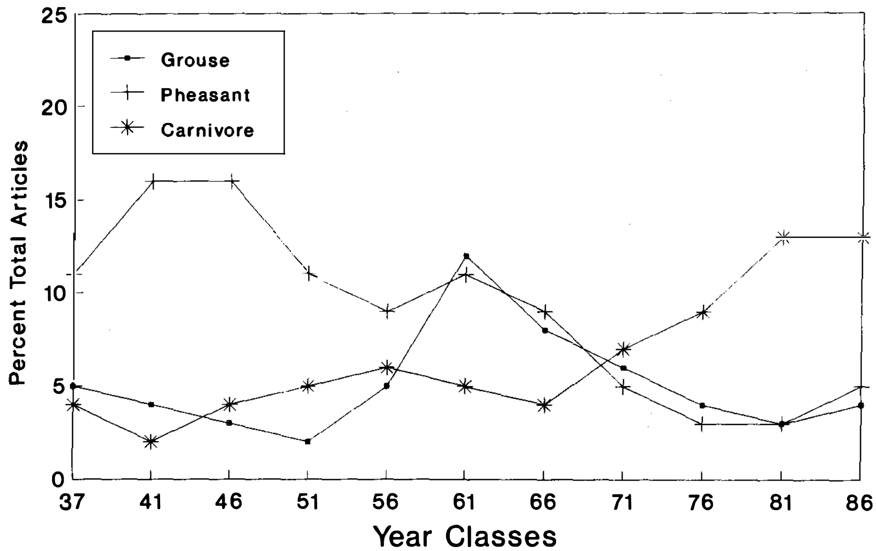

Figure 2. Percentage change in total TWS publication articles for grouse, pheasant, quail and carnivore subject categories, 1937–1989.

the species subject areas of Artiodactyla (includes deer, elk, moose, etc) and waterfowl (ducks and geese). Currently, Artiodactyla and waterfowl totaled over 41 percent of all published articles after reaching a high of 49 percent from 1966–1970.

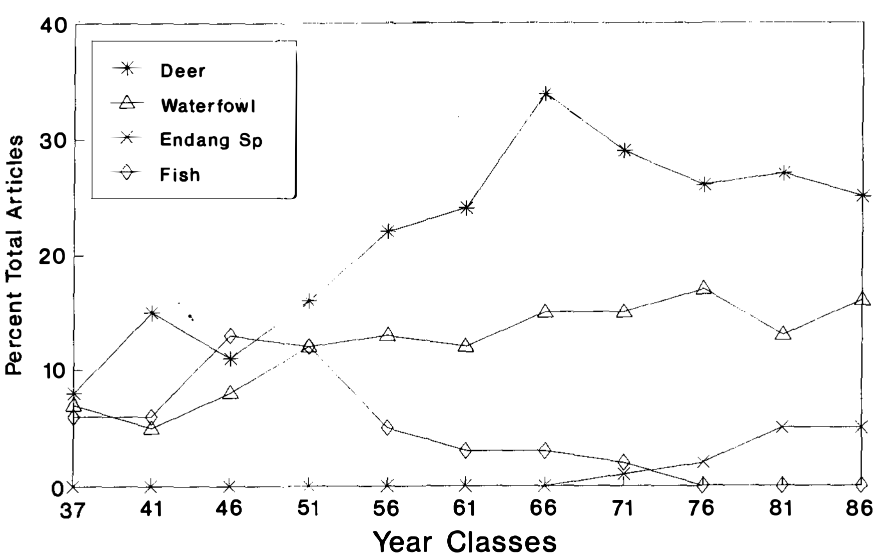

Figure 3. Percentage change in total TWS publication articles for deer (Artiodactyla), waterfowl (ducks and geese), endangered species and fish subject categories, 1937–1989.

Even with the consistent high percentage of Artiodactyla and waterfowl papers, a disturbing decline in the breadth of articles was apparent (e.g., loss of disease articles to other journals over time). This preponderance of effort is in contrast with the current historically high effort (5 percent) on endangered species.

The game and nongame categories have demonstrated rather constant relationships as well as relatively constant levels through time. These relationships between contributions of game and nongame occur in spite of public value changes associated with *Silent Spring*, the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and E. O. Wilson's *Sociobiology*, and the important developments in association with the emergence of the Society for Conservation Biology.

Discussion

How responsive have "we" as a profession been to both the wildlife resource and public needs? The data presented here seem to argue for a greater concordance between the wildlife resource/public needs and the publication record of the profession in its early years. The importance of game during the early years of the profession is suggested by Leopold's *Game Management* (1933) and the common state resource agency moniker of Fish and Game Department (*see also* Bolen 1989). Further evidence for similar responsiveness may be found with the first articles on DDT-wildlife relations in 1946, shortly after the pesticide's introduction into the United States in 1942. In fact, a series of seven articles on DDT/wildlife effects in JWM in 1946 represents efforts by the profession to lead the way into a new realm of environmental toxicology and wildlife.

However, an objective review of our most recent data seem to show that since the 1960s we may have fallen behind in our profession's responsiveness to both changing societal values and changing ecological paradigms. Wagner (1989) eloquently argued that "our profession has failed to adjust . . . and recognize . . . the full range and weight of societal values." The 1985 national survey of fishing, hunting and wildlife associated recreation clearly demonstrates that, in both expenditures and recreational participation, nonconsumptive "uses" of the wildlife resource exceed hunting in both direct outlays and participation by wide margins (U. S. Fish and Wildlife Service 1988). Leopold (1940) had identified the necessity to be responsive to changing societal needs when he noted that, "Our profession began with the job of producing something to shoot. However important this may seem to us, it is not very important to the emancipated moderns who no longer feel soil between their toes." These prophetic words undoubtedly describe the situation which underlies the resource conflicts and changing demands of today. Although Leopold saw the "handwriting" of changing public perception "on the wall," our profession has shown (via its publications) a singular lack of attention to understanding societal values. Our data have shown that the arena of conservation education/human dimensions has been represented at minimal levels (Figure 1) since the inception of our profession. Would a successful manufacturing company avoid knowledge of its primary markets? We think not. At least one that intends to stay in business!

Have we been responsive in our consideration of the total wildlife resource in TWS's publications? We believe that the data incontrovertibly show the answer to be no. Once again the earliest leaders of our profession pointed the way on this question. Leopold, in *Game Management* (1933:403), observed that "the objective of a conservation program for non-game wildlife should be exactly parallel (to that of a game management program): to retain the average citizen the opportunity to see, admire and enjoy, and the challenge to understand, the varied forms of birds and mammals indigenous to his state. It implies not only that these forms be kept in existence, *but that the greatest possible variety of them exist in each community.*" Leopold (1940) further noted that even in 1940 wildlife research programs were out of balance and observed the paucity of research on rodents and other types of wildlife. The Statement of Policy which appeared in Volume 1 of JWM (Bennitt et al. 1937) explicitly states that "It (wildlife management) consists largely of enrichment of environment so that there shall be maximum production of the entire wildlife complex adapted to the managed areas. Wildlife management is not restricted to game management, though game management is recognized as an important branch of wildlife management. It embraces the practical ecology of all vertebrates and their plants and animal associates. While emphasis may often be placed on species of special economic importance, wildlife management along sound biological lines also is part of the greater movement for conservation of our entire native fauna and flora." Similarly, Allen's Report on the Committee on North American Wildlife Policy (1973) observed that frequently nongame species have had only incidental attention. A new trend is in progress wherein game and fish agencies are getting broader responsibilities as wildlife agencies. Ways are being found (albeit small) to supplement their license-based funding. Hence the urban dweller should expect substantial amounts of these nonlicensed-generated funds to be spent on the species that help bring open spaces to life. And finally the Conservation Policies of TWS (1988) points out the importance of fostering research designed to clarify the complex biotic relationships of ecosystems as well as research on the biology of endangered species as a means to achieve their restoration, management or protection.

Figures 3 and 4 clearly show that we have given short shrift to a broader vision of wildlife species. Although almost 20 percent of articles currently deal with nongame wildlife, a good portion of these are considered only from the standpoint of animal damage problems and at least 25 percent of this total represent endangered species articles. Our data mirror those from other independent evaluations. For example, Kadlec (1978), Capen (1989), and Wagner (1989) have shown from admittedly different samples that TWS publication seem to be missing a healthy nongame component. Crawford's (1976) optimistic appraisal of the status of nongame wildlife in university research programs noted that over 826 nongame theses were completed or were underway at 38 universities in the U.S. during the period 1965–1975. We certainly would suggest that given the number of U.S. universities (public and private) with ecologically-oriented research programs, this number (826) must be considered a conservative estimate. Our data from this same time period show that only 207 nongame articles were published of which not all were theses contributions. Given that some (too many) theses never see the light of day, and that some theses may produce more than one publication, we would predict that at least 400 of the theses would be available for submission to TWS for publication. Knowing that the 826 theses are at best an overly conservative estimate, we might legitimately ask, where is the research being published?

There are some of our colleagues that also might counter that these missing research papers may be in other publication outlets. So what? We believe the fact that such

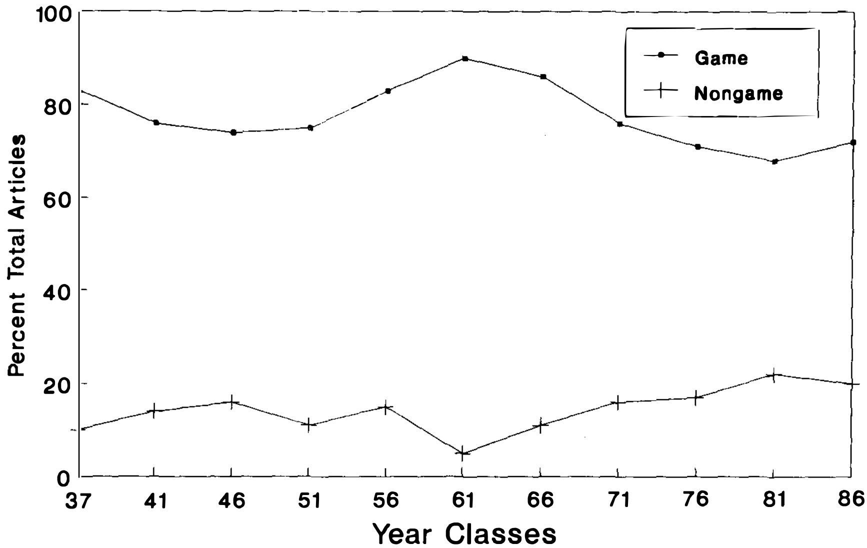

Figure 4. Percentage change in total TWS publication articles for game and nongame subject categories, 1937–1989.

an obvious distinction occurs in our literature is symptomatic of a more deeply rooted problem. The problem being that the scope of our science has grown more narrow with time and we may not be able to see the forest for the trees. The JWM can point with pride at the well-known contributions of some of the preeminent ecologists of this century, L. Cole, D. Lack, L. Siivonen, W. E. Ricker, W. Moran, P. Errington, G. E. Hutchinson, J. J. Hickey, W. Marshall and V. E. Shelford. Most of these contributors participated in a landmark symposium on population cycles published in Volume 18 in JWM in 1951. Have our publications become "bound up" with single species articles focusing on techniques with little attention paid to hypothesis generation and testing? Are we never to venture into the world of modern questions of the effects of habitat fragmentation and corridor disruption on wildlife communities? Is the "ecosystem" only a construct to be taught in university ecology classes (*cf* Kadlec 1978, Graul et al. 1976)? Will the twin millstones of the "Aardvark" and the "Arcadia" Principles (Hunter 1989) forever hang over us?

We thing the answer to all of these questions is *no*! We also believe that in order for the TWS to remain relevant to modern conservation (*in sensu* Bennitt et al. 1937, Leopold 1940) we have no choice! The development of the *Society for Conservation Biology* and the *Journal of Applied Ecology* is clearly a response to a scientific void created by our profession's infatuation with techniques and narrow subject matter scope. Hickey et al. (1987) reported on the marketing impact of the celebrated October 1963 number of JWM which contained the 362-page grouse management symposium. Membership in TWS rose by 17 percent in response to the publication of this issue. Wouldn't the current membership committee love to see that kind of growth? Apparently, good science attracts scientists. We must find a way to address practical conservation questions using the latest in ecological theory. We must also seriously respond to our changing publics' needs. Is there room in any of our publications for a serious discussion of policy on the care and handling of captive and/or experimental animals? Our cousin academic societies have all developed policy statements on this topic. Are we keeping up with public values?

Finally we strongly recommend that the editors of our publications take steps to change the diversity of subject matter presented to our membership. We do not believe that this should be accomplished via the denial of quality science on game animals, but rather we should take positive steps to encourage nongame and endangered species papers, ecosystem studies, discussions of habitat fragmentation, human dimensions and public needs assessments, incorporation of techniques-oriented subjects into research and management papers (therefore minimizing techniques papers), hypothesis testing and other papers that broaden our professional growth.

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Special Session 4. *Resource Management Lessons from Unpredicted Events*

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Introductory Remarks

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The first round of the conservation battle, fought over the past 100 years, has been won. The late 1800s witnessed the height of the American Industrial Revolution. There was rapid economic growth, facilitated by great stores of natural resources whose use was unconstrained by protective laws or regulations. There was a vast public domain in the west to dispose of. Natural resources were used as incentives to settlement. The result was speedy and dramatic alteration of the natural environment and rapid decline in populations of game animals, birds and fish. Unregulated killing and habitat destruction were responsible for the decline. America's natural resources were being highgraded. The problem was to refine the laissez-faire system to provide for protection and management of resources. The conservation movement responded with reservations of land from the public domain for conservation purposes, management concepts of ethical and wise use of public resources, and protective laws and regulations.

The conservation idea of wise and managed use of forests and wildlife has become the rule for most state and federal resource management agencies. One result is that big game populations are at recent historic highs.

Conservation has worked for the most part because it has made sense, it has defined reasonable use and it has been practiced with wisdom. A more fundamental reason conservation has worked is that resources have been plentiful—there has been slack in the supply system. With wise use and sharing, there has, in general, been plenty for all. Reasonable, protective measures have unlocked the power of renewability and a workable balance has been restored.

Winning the second round of the conservation battle just beginning will be tougher than winning round one. The next two decades will be a time of significant world and national population and economic growth. World population will increase about a billion per decade to 10 billion by 2050. National population will increase about

30 percent by 2050, to 340 million. A five-to-ten-fold increase in world economic activity in the next 50 years is projected to meet the basic needs of the future population. The implications of that growth for an already stressed planetary environment are at best problematic, and at worst potentially catastrophic. Resources will likely be oversubscribed—the slack will be out of the national and global systems. In the last 100 years the conservation challenge was resource protection and management in an undersubscribed system. In the future, the problem will be to preserve environmental quality in a system that will likely be oversubscribed internationally and nationally. Conservation must occur in the context of global and national economic growth, structured to keep environmental transformation within safe limits. Since the slack will be out of the supply system, activities will occur on the margins of human and resource tolerances. The margins for environmental error will become narrow.

In this general context, I see four major trends that will contribute significantly to America's conservation challenge in the 1990s:

1. Increasing demand for natural resources services and products;
2. Increasing strength of the environmental movement;
3. Increasing value on personal freedom and participation; and
4. Increasing pace of change.

America's population is growing about 15 million per decade and economic growth averages about 3 percent per year. Natural resources products play a key role in growth, and product demand will not be less than it is today. At the same time, there is a growing perception that civilization is colliding with the environment and the environment is losing. More Americans are willing to take their cases to government to protect the environment, or to argue against perceived threats to it. Finally, the pace of change is accelerating as its primary driving forces, human population, economic growth, and the information revolution, gain momentum.

Natural resources managers will not be alone in trying to figure out effective responses to competing forces and rapid change. American business has been at it a long time. Most successful businesses have adaptive, flexible strategies that respond to the mainstream values of customers and employees. They also emphasize decentralized organizations, participative management and customer and employee rights—some good lessons for making natural resources management work better in a democracy.

In our rapidly changing world of natural resources management, we can be sure of increasing surprises and uncertainty. Some issues and trends can be anticipated and turned into opportunities, and we should work hard at making good projections and long-term plans. But we must also improve our ability to respond effectively to unpredicted events, whose frequency and effects will increase with the rate of social and technological change. Adaptive leadership and management should view management practices as experiments, our best shots at responding to problems or opportunities; our best shots that are going to be wrong a lot of the time. The important points are:

1. We must learn the constructive lessons from our best efforts;
2. We must keep our options open to accommodate change; and
3. We must maintain our ability to change and adapt effectively.

In this session we examine the great, unpredicted natural resources events of the 1980s, the Yellowstone fires, the Alaska oil spill, the Mt. St. Helens eruption and

Hurricane Hugo, for their management lessons. The hope is that the important management lessons will be understood, accepted and supported in order to strengthen adaptive management and improve the prospect for continued conservation success in the 1990s and beyond.

Lessons From the Yellowstone Fires: Do You Trust Talking Animals?

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In the wildly popular and spectacular Walt Disney movie *Bambi*, the animals of the woods were confronted with a crisis of enormous proportions when a raging fire threatened to destroy all of the wildlands and wild things portrayed in the film. I saw the movie when I was about eight years old and if my memory serves me, indeed a few animals, and certainly much of the plant life in that glorious Disney animation, were consumed by the flames. Much to the disgust of some male teenagers seated behind me, I sat crying during that scene. Only after the star fawn survived, and was ultimately nurtured into adulthood by the wise old stag of the forest, was I able to regain my composure and whatever aplomb an eight year old boy may have.

I retained the vivid images portrayed in that film for many years. Not until my college years did I discover that far from being all bad, fires were sometimes good, even necessary, to perpetuate wildlife and wildlands. That knowledge was the first lesson Bambi taught me, that sometimes the conventional wisdom I learned as a child was partly, if not wholly, a first-rate myth.

The second lesson took a lot longer to learn. I didn't learn it until the fall of 1988 when I was given a copy of the original book *Bambi* (published in this country in 1928) by one of the great storytellers, Felix Salton. The full title, by the way, is *Bambi: A Life in the Woods*, which sounded intriguing to me. Tired of the endless rhetoric and the even more endless articles being written about the Yellowstone fires (a lot of that was fiction too), I eagerly plunged into this classic children's book only to find out it wasn't necessarily ''just'' a children's book at all. In fact, there were some wonderful ecological lessons in the text, even though the science of ecology was in its infancy when the book was written. In that book, I found a wonderful balance of humanized words and natural animal behavior, all combined in a sensitive philosophy of life and death in the woods. But as wonderful as those messages were, the biggest lesson I learned came when I discovered there was no fire in the book at all. Disney had falsified Salton's classic story and invented the great fire! To be sure, the book told of a frightening threat to the woodland creatures but that threat came from the human beings in the story, not from Mother Nature.

Walt Disney put one over on us by blaming nature for a crisis when the blame should have really been shouldered by humans.

The argument over the Yellowstone area fires of 1988 had, and continues to have, similar elements. Some people, including scientists, seek to blame Mother Nature for those awesome flames. But others, including scientists, believe the blame should have been shouldered by humans. For one important sector in our culture, however, there was never any doubt.

The media looked hard for a human villain behind the fires while the whole area was being subjected to nature's intensity and the largest aggregation of firefighters in this nation's history. And this time, America's media played the role of Walt Disney and may have put another one over on Americans.

In recent years the media have recognized Yellowstone as superb copy. Our grizzly bears are as famous as prime time media celebrities. Our other endangered animals—whooping cranes, bald eagles, peregrine falcons—and the wolves we lost but want to restore, have become icons of the wildlands conservation movement. In Yellowstone, it's resource management in a fish bowl. Just reflect on the fires of 1988, which were daily national news during that fateful summer. In our own reflections, we observed that the fires were seen in many different ways. Many saw them as a national tragedy, but others saw them as a natural wonder. Scientists saw them as a unique scientific opportunity, and historians saw the fires as the most significant event in the history of the nation's national parks. Some citizens saw the fires as a monumental public policy disaster, while others argued they were proof of enlightened public policy. But, in general, the public perceived the fires the way the media portrayed them: as a singular disaster occurring in Yellowstone National Park.

On the news, sometimes it became clear momentarily that a fire was burning into the park from somewhere else, or leaving the park to burn some national forest lands. But most of the time the fire itself—especially when it was behaving photogenically—was the big news. How many acres did it burn? Did people run screaming from it? Was it killing lots of animals? How "bad" was the so-called destruction? Who was to blame? (It was generally assumed there must be someone to blame; Mother nature could not have acted alone.) More important, how will we punish them?

Now I'm not saying that some of these questions are not interesting. Some of them may even be important! But as Dr. Conrad Smith of the School of Journalism at Ohio State University has pointed out in his rigorous studies of media accuracy in the Yellowstone fires, journalists told us a lot of stuff about the fires but they missed the big stories: important stories like the ecological story, or the legitimate public policy story, or even the real wildlife story. According to Dr. Smith, "The coverage . . . was superficial and stereotypical." "Despite the best intentions, the reporters [were] guilty of two basic journalistic sins: one, leaving the incorrect impression that the whole park had burned down; two, fanning the political controversy about fire policy without explaining where the policy came from and whether it really made a difference." And I'll always remember Dr. Smith's telling observation that "the media abhors complexity."

In journalistic terms, the media treated the Yellowstone fires as a disaster-victim-villain story. National Park Service policy became a staple of news coverage. It served a key media purpose by providing convenient villains: park managers, who were clearly too stupid to know that the fires should be put out. This bypassed the important fact that they could not be put out. Victims were found easily, and some of the more memorable quotes of the summer came from individuals dragged off their bar stools. Scientists proclaiming the value of the fires to the maintenance of the ecosystem were often treated as unfeeling eggheads who had cavalier attitudes toward the obvious destruction of one of America's most beloved places.

On one evening newscast in September we all viewed the vivid images of smoke and flames, and mile after mile of blackened forest that came to be known as "moonscapes" or "biological deserts." We heard the crackling and hissing of the fire and the explosive sound of torching trees. Then, NBC's anchor Tom Brokaw announced to the world that "This is what's left of Yellowstone tonight."

So lesson number one from the Yellowstone fires is this: Don't trust talking animals, and if that animal is quoted in the press, trust it even less.

We should, however, probably footnote that lesson. For all the satisfaction of righteous vengeance, and as much fun as it is, I didn't come here just to do some media-bashing. There are legitimate lessons to be learned. To most of us involved in the 1988 fires, the fires added a whole new dimension to the interaction between resource managers and the press. What is the media's responsibility in reporting large or small resource events? My interpretation—admittedly biased following the Yellowstone fires—does not necessarily coincide with what the best reporters believe and seldom coincides with what the worst reporters think. Is it to report what is newsworthy or what is significant? The two are not always cut from the same cloth. Will we be served entertainment, or fairness, accuracy and balance? How will we know the difference?

I think we have to assume that it's a good idea for agency people to try to get across the kind of information about resource issues that will truly inform and educate the public.

The Yellowstone fires were an unprecedented news story, filling the front pages of America's newspapers for nearly three months. At one point in September, 1988 there were seven television satellite up-link trucks parked in the shadow of the park headquarters building. In the 15 months following the fires, Yellowstone had more than 5,000 media contacts. The demand for stories, for new angles or an unusual twist, for sensational videotape or perfect photographs, was extraordinary. But it was ordinary bureaucrats who were the marketeers and we learned a few lessons, often the hard way.

For example, we learned that most resource issues in today's world are neither black nor white but instead are painted in shades of gray. Real reporting is a process of analyzing those shades. But most reporters want only to deal in the blacks and the whites. "Tell me now, Mr. Varley is what you are doing right or wrong? If you are doing it this way and that other guy that way, then one of you must be right and the other must be wrong." Right? But in real life it's not right or wrong, it's just different. We who deal in the realities of gray don't have the luxury of simple answers.

The frustration of trying to deal in television's notorious "ten second sound bites," or in "one-liners" for the *Washington Post*, is immense. You know in advance that only the most clever, or the most powerful, or the most provocative, or the most controversial statements will be used from the hours of taping or interviewing that might be done. You know that if you're lucky, and your viewpoint is represented at all, the decision will be made 2,000 miles away, by someone in a studio, someone who will take the tape of a 30-minute interview and find the 10 seconds he likes best to prove a point he thinks matters most.

You also know in advance that journalism will give you a new title. You are now an "expert." And you also know that according to media law, for every expert there is an equal and opposite expert. They must go to someone else for a contrary opinion. The media dubs this "story balance," and indeed sometimes it is. But sometimes it is not. Upon hearing the largely positive ecological story of the Yellowstone fires, the media seemed genuinely frustrated after hunting through the corridors of the regional universities and being unable to find a qualified ecologist with a dissenting opinion. That was just great; that meant that everyone generally agreed. Right?

Wrong. That's when some of them resorted to the area bar stools for their contrary viewpoints. So they ended up with a videotape of a bizarre contrast between a genuine real-life expert, perhaps one with 25 years of experience and highly respected in his field, being rebutted by someone with no more qualifications than a moving mouth and a high decibel level. Many people take what they see on television as truth, and this emphasizes the importance and the power of putting someone on television even though his arguments bear little resemblance to reality or to scientific fact.

We learned, as well, that the media is no place for amateurs, whether they be interviewers or interviewees. Amateurs from within the agencies, undoubtedly floating four inches off the ground at the prospect of being quoted in *The New York Times*, would frequently speak up with naive opinions or grapevine information that would later waste vast sums of time and money in damage control by the agencies. But on the media side, the *Wall Street Journal* sent a reporter who specialized in commodities trading markets to cover the fire story. I inquired of his qualifications to be writing about the subject at hand and it turned out that he was a fisherman, which I surmise fully qualified him in the *Journal's* eyes to do the job. When he asked me what ''plant succession'' meant, I knew we were in trouble, and the *Journal* did not disappoint us.

We also learned that about 10–20 percent of the journalists were very good at conveying accurate information, providing balanced coverage, and doing a pretty good job of converting jargon and complexity into plain English. Even when these people were critical of our actions in their stories, these reporters proved themselves, over time, to be too valuable to ignore. Sometimes their criticisms were even accurate, and we learned something. We have always nurtured the ones who worked hard at getting the best version of the truth. Of course, for those of us who are still believers in a bell-curve distribution, if 10–20 percent of the media are superb, we must deduce as well that 10–20 percent must be despicable. This fact was also borne out during the fires of 1988 and even now, some 20 months later, I still find myself having violent thoughts about some of them.

And in the end we learned many lessons beyond what to believe, or not believe on television. We learned a lot about what can genuinely be called a human tragedy versus what can genuinely be called an ecological event. They are two separate issues.

Now, and far into the future, we will make a quantum leap in our knowledge and our ability to understand the relationship between fire and species, habitats, and indeed, whole landscapes; about how and when to fight fires, and when not to.

We learned a lot about both the strengths and the weaknesses of relationships between agencies and institutions. These relationships were tested to their limits, and in the final analysis there were aspects to celebrate, aspects to forget, but in all cases, aspects to learn from.

And for all of this learning we did, who of us involved during those great fires would have done some things differently? The answer, in my view, is that all of us would have done some things differently if it were to happen again.

Would these things done differently have altered the outcome? Probably not, in my view, because the answer is problematic and one which we will never know.

So against this backdrop of one of nature's most spectacular events, one in which multiple stores were played out at once, I submit that one of the best stories was not about Bambi, or Yogi, or even Smokey, but about how the American public, as ''educated'' by the media, reacted to the fires. Agencies and institutions must be prepared to work with, rather than against, the established conventions of modern media. For it's not a failing of the American media that very few people knew enough about fire ecology, or fire policy, or fire fighting to intelligently evaluate the news. It is, rather, a failing of our cultural systems that neither the press nor the American public were sufficiently prepared, or properly educated, to react intelligently to the *idea* of the fires: learning to spot the tell-tale signs of bad reporting—and good; learning as well to see through the double-talk of bureaucrats or politicians—or the truth; being able to tell barroom biology from the real stuff; and learning to *think* about what we are watching or reading; that is about the best we can hope for in these days of the ''new journalism.''

Lessons from Yellowstone: An Administrative Perspective

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Background and Causes

The fire season of 1988 was severe in many parts of the western United States. Near record acreages were burned, and we spent more than one-half billion dollars on suppression efforts. Rehabilitation and other follow-up needs were logistically massive and very costly. Although there were many fires burning in other locations, the Greater Yellowstone Area was the focus of public concern because of its special place in the hearts and minds of America and the world.

Of the 249 separate fires that occurred in the Greater Yellowstone Area, only 28 lightning-caused fires were managed as prescribed natural fires under the existing policies of the National Park Service and the USDA Forest Service. Though the public perceived that the majority of the fires were prescribed natural fires, that was just not the case. Uncontrollable by any conventional means, the spectacular flaming fire fronts were vividly depicted by the news media throughout late summer and fall. Visitors were inconvenienced and frightened, some seasonal businesses suffered and some residents were traumatized as the fires spread around and through their communities. Professional and political debates were triggered that linger on today.

The secretaries of Agriculture and Interior established a fire policy review team, which issued a final report on May 5, 1989. The report supported the concept that prescribed natural fires have a role in managing wildlands. The recommendations in the report did strengthen the procedures to implement the policies in a more uniform and professional manner.

The Forest Service fire policy has not changed since 1978, from the standpoint that there are still only two types of fires. Fires occurring on the National Forest lands are designated as either *wildfires* or *prescribed fires*. A *wildfire* is any wildland fire not designated and managed as a prescribed fire within an approved prescription. A *prescribed fire* is any fire burning under preplanned. specified conditions to accomplish specific planned objectives. It may result from either a natural ignition (prescribed natural fire) or be ignited by land managers.

The objective of Forest Service fire management policy is cost effective integration of fire protection and use in land and resource management planning and implementation. The objective of wildfire suppression is to suppress all wildfires at minimum cost and damage, consistent with management direction. Prescribed fires are used under specified conditions to safely and economically achieve land and resource management objectives that are identified in forest plans.

Forest Service fire suppression policy is to suppress wildfires in a timely, energetic, and thorough manner, with a high regard for public and firefighter safety. Every wildfire requires a quick, effective response, based upon established fire management direction and cost efficiency. We consider suppression strategies ranging from prompt control that minimizes acreage burned, to more indirect methods of containment and confinement when these alternatives are less costly than control, and human life and property are not threatened.

When a wildfire escapes initial attack, an escaped fire situation analysis is prepared to provide an analytical basis for determining the best suppression response in that particular situation. In the analysis, firefighter and public safety, values at risk, suppression costs, environmental effects and social and political concerns are evaluated.

Prescribed fire plans are prepared before any prescribed fire is started. Personnel conducting prescribed fires must meet stringent training and experience requirements. If a prescribed fire exceeds the prescription and cannot be brought back into prescription with project funds, it is declared a wildfire and suppression action starts.

The Lessons

1. A policy that can't be explained simply in 30 seconds or less is useless if put to the test of public understanding in a crisis.
2. Any firefighter or catdriver on the line has more credibility with the media than a dozen overhead persons.
3. Committees set up to meet occasionally in order to coordinate policy and programs after thorough evaluation and review of fairly complete information are less effective for decision making day to day in a fast moving emergency situation.
4. The public can understand an agency having tried and failed; but they have no forgiveness if they think we didn't try, or worse yet, don't care.
5. Too much of a good thing is still too much.

Closing

We need to promote awareness of our fire management and land management concerns to our neighbors and interested public. People do not care what you know; they want to know that you care. The public wants to know that the manager's concern for their welfare and quality of life is the guiding factor in decision making. The fire program must reflect these considerations to retain public support.

The Wildfires in the Northern Rocky Mountains and Greater Yellowstone Area—1988

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Much of society views large wildfire occurences as somehow different from hurricanes, volcanoes, earthquakes and other natural disasters. The large forest fires in the western United States during summer 1988 clearly showed that, under some severe conditions, forest fires are not preventable and not controllable. Although the 1988 fires were larger and more spectacular than any in recent U.S. history, such conditions will occur again and a similar disaster will be witnessed. Neither willingness to prepare for the next event, nor support for further understanding of such events is evident.

What happened in 1988? Some would begin the story in mid-June when lightning-caused fires in some Forest Serive wilderness areas and in Yellowstone National Park were allowed to burn under prescriptions designed to allow fire to take a more natural role in the ecosystems. Because 12 of the original 20 fires soon died out, managers felt the fire environment and fire behavior were similar to the previous several years. By mid-July, though, one of the largest mobilizations of fire control personnel and equipment began to mount. Additional human- and lightning-caused fires started, and soon a major disaster unlike any since 1910 began to unfold. The press, special interest groups, politicians, business persons, landowners and even members of the fire suppression community began to condemn National Park Service and Forest Service officials, wilderness management policy, fire policy and control strategies.

What Happened?

Leading up to the 1988 fire season, the West in general had gone through two consecutive years of drought. Although the drought index for the Greater Yellowstone Area was "mild moist" in August 1987, it jumped to "mild drought" by December after a record dry September and October. By April 1988, the Greater Yellowstone area was in "moderate to severe drought." Even though May had well above-normal precipitation, the drought index was "extreme" by mid-June. No relief occurred throughout the summer. Other weather factors adding to severe fire potential included above-normal temperatures, persistent low humidities, high winds and dry lightning storms. The relative humidity at Tower Falls, for example, reached 6 percent in August. In addition to all this, a series of intense, dry cold fronts crossed the area; wind gusts from these exceeded 60 miles per hour (97 kph).

Indexes used by fire management personnel to track and predict expected fire behavior were more severe than anyone could remember: Critical index levels occurred earlier than previous severe seasons reached higher levels, and showed a steeper rate of change. Fine fuel moisture of between 3 and 5 percent occurred.

These weather conditions coupled with expansive areas of primarily lodgepole pine forests, much of it exhibiting mature age classes, was an explosive combination. Records kept since the early 1900s showed no evidence of fires the sizes of those experienced in 1988. There is good evidence that many of these stands back to large fires before 1850. An additional factor was the large component of dead trees in some stands resulting from the occurrence of mountain pine beetle.

Fire fighters and suppression experts were overwhelmed by the scene they witnessed. Some of the fire behavior included:

- Ten-mile (16.1 km) advances in one day.
- Sustained spread rates of 2 miles per hour (3.2 km/hr) in timber.
- Fire jumping barriers, such as Yellowstone Canyon, the Madison River, highways and building complexes.
- Unprecedented spotting and cumulus cloud cap development.

Suppression techniques made little difference much of the time. Many strategies were designed for containment, not direct control. Much confusion occurred, even among fire fighting forces, about constraints on suppression techniques as a result of concerns for ecosystem impacts and limits on suppression because the situation was so hopeless. The results were truly historic. The major fires looked like this: Storm Creek—110,000 acres (44,500 ha); Fan—25,000 acres (10,100 ha); Smoke Complex—225,000 acres (91,000 ha); Clover-Mist—415,000 acres (168,000 ha); Mink—130,000 acres (52,600 ha); North Fork/Wolf Lake—510,000 acres (206,400 ha); Huck—225,000 acres (91,000 ha); and Fayette—39,000 acres (15,800 ha). When the weather changed and the smoke began to clear, there were 1.41 million acres (0.57 million ha) burned within the Greater Yellowstone Area. Major reviews were begun on (1) suppression activities, (2) fire effects and rehabilitation, and (3) Federal fire policy on wilderness and park lands.

And what of the fire effects? There is no question that these fires impacted business, private property and investments, homes, and national park facilities. Effects on the ecosystems are more complicated, but several things are reasonably obvious. The fires did not burn uniformly as many were led to believe by early press reports; for example, about 57 percent of Yellowstone Park fires were in the crown, 37 percent were on the surface, and 6 percent were in the grasslands. Closer examination shows a wide array of fire treatments for almost total vegetation removal to very light surface fires. Flying over the Greater Yellowstone Area, one also sees an interesting mosaic of green islands within the fire-affected areas. Ecologists generally agree that fire is an integral part of the Greater Yellowstone ecosystem and that the vegetation and animals are well adapted to its occurrence. This does not mean fire occurrence of this magnitude in Yellowstone is acceptable, but real or perceived ecological effects are not the primary reason. In fact, a major concern of some ecologists is that natural postfire processes be allowed to continue without artificial seeding and feeding programs.

What Did We Learn From This Disaster?

- The potential for large, spectacular forest fires exists in the Northern Rocky Mountains, and fires will occur when the right combination of weather and ignition is present. This can occur with or without natural prescribed fire programs.

- Many other regions of the United States have a similar fire occurrence potential, and it is increasing as a result of new ignition sources, fuel accumulation and insect-caused mortality.
- When land management agencies are lacking in preplanning, public involvement, and coordination, traditional attitudes supporting "fire fighters" may be converted to strong criticism of fire management organizations. This was the first major fire disaster where such broad criticism of agencies occurred.
- The public in general supports and understands the need for and benefits from prescribed burning, but there is considerable disagreement on "natural" fire programs.
- Achieved a greater awareness of what is possible and not possible in fire suppression actions.
- Discovered the importance of multiorganization cooperation.
- Found that a considerable amount of fire behavior and fire effects mechanisms are not understood.
- Found that the public's attention span relative to natural disasters is as short lived as ever.

Two remaining issues received new emphasis and interest because of the 1988 fires. One relates to various definitions of "natural" and how objectives for natural ecosystem management are defined and addressed. For fire management, this means there is support for prescribed burning in wilderness and national parks as opposed to programs that depend upon lightning-caused ignitions. The other issue is how "natural" is defined as it relates to fire history. Many feel there has been inadequate analysis of fire occurrence, timing, and size and the role of aboriginal fire.

The Exxon Valdez Oil Spill: A Land Manager's View

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On March 24, 1989, the supertanker *Exxon Valdez* outbound from Valdez with 53,094,510 gallons of North Slope crude oil grounded on Bligh Reef, spilling approximately 11,000,000 gallons of oil into Prince William Sound; the largest oil spill in U.S. waters.

At the time, I was Supervisor of the Chugach National Forest, and remained in that position through the first six months of the response and damage assessment efforts. In August, it became apparent that coordination of oil spill activities was a full time job, and I was asked to assume that role.

In the response to the oil spill, the Forest Service participates on several committees in support of the Federal On-Scene Coordinator (FOSC) to:

- Provide resource information and priorities for cleanup;
- Assess the effects of cleanup on National Forest resources;
- Assure compliance with Section 106 of the National Historic Preservation Act;
- Assure the removal and proper disposal of solid waste; and
- Approve land uses associated with administering cleanup.

Under provisions of the Comprehensive Environmental Response, Compensation and Liability Act, the Secretary of Agriculture has been designated a trustee for resources damaged in the oil spill. The regional forester for Alaska is representing the secretary in the damage assessment process.

Background

In Valdez Arm, the *Exxon Valdez* encountered icebergs that had calved from Columbia Glacier. It requested and was granted permission by the Coast Guard to turn southeast out of the tanker lanes to avoid the ice. Before it could turn back into the outbound tanker lane, it grounded on Bligh Reef holing eleven cargo tanks and three of seven segregated ballast tanks.

Oil spread southwesterly through the Sound, which is about the size of Chesapeake Bay. It is one of the largest undeveloped marine ecosystems in the United States and has one of the continent's largest tidal estuary systems.

The Sound is within the boundaries of the Chugach National Forest. Eighty percent of the land surrounding the Sound and islands within it are the national forest ownership and have a shoreline of 3,500 miles. And 2,100,000 acres of national forest in the western Sound were designated the Nellie Juan-College Fiord Wilderness Study Area in the Alaska National Interest Lands and Conservation Act of 1980.

On the seventh day of the spill, oil flowed out of the Sound, continued southwest through the Gulf of Alaska around the end of the Kenai Peninsula and along the Alaska Peninsula. By the 56th day currents had transported the oil approximately

470 airline miles from the point of the spill. Along the way it deposited oil over more than 700 miles of shoreline, and spread across 10,000 miles of water surface. In addition to the Chugach National Forest, the oiled area includes Kenai Fiords, Katmai and Aniakchak national parks and Kodiak, Alaska Maritime, Alaska Peninsula and Becharof national wildlife refuges. The area is pristine in character, with islands dotting secluded bays and fiords. Majestic glaciers, headlands and mountains rise out of the sea. The marine environment nourishes a lush, green landscape and supports an abundant variety of fish and wildlife. This combination of physical beauty and abundant wildlife attracts a growing number of tourists to the area. It also supports one of the world's largest commercial fisheries, and several small, isolated communities rely on the fish and wildlife to sustain their subsistence lifestyle.

Causes

Approximately 8,700 tankers had exited the Valdez Terminal prior to the departure of the *Exxon Valdez*. The tanker's grounding, resulting spill and wide spread of oil are the consequences of a complex combination of legislative, regulatory, administrative, planning and operational actions that began with the decision to build the Trans-Alaska Pipeline System (TAPS). Review of all aspects of the oil spill is underway and a number of potential causes have been revealed.

Use of double bottoms on tankers as protection against oil spills was proposed as a condition of the construction of the TAPS. Shipping and oil interests objected to the proposal because of the marginal gain in safety at a significant increase in capital cost. The proposal to require double bottoms was dropped and replaced with a requirement for segregated ballast tanks along a portion of a tanker's side. The Coast Guard also offered the alternative of tighter operational requirements.

These requirements included the use of separate lanes for inbound and outbound traffic and the use of licensed pilots from the port to Rocky Point in Valdez Arm. As in the case of the *Exxon Valdez*, the Coast Guard has relaxed the requirement for tankers to stay within prescribed lanes. Pilots originally guided tankers all the way through the sound to Hinchinbrook Entrance. This requirement was modified because it is hazardous to transfer pilots at the entrance. Initially, the Coast Guard installed one of the best radar surveillance systems with very high resolution for bearing and range. Due to reduced funding, this system was replaced with one that was cheaper to maintain but had lower resolution for bearing and range. Up until 1986, the Coast Guard monitored traffic to the limits of radar coverage and plotted the position of each ship every six minutes. Since 1986, tankers have only been monitored and plotted in Valdez Narrows.

Several oil spill contingency plans were in effect and had a bearing on the response to the spill. These included the National and Alaska Regional contingency plans, the Prince William Sound Pollution Action, U.S. Fish and Wildlife Service, Alaska Department of Environmental Conservation, the Alyeska Pipeline Service Company (Alyeska) Plans and the Wildlife Protection Plan for Alaska. These plans are tiered and generally do a good job of defining notification procedures and job descriptions, but are otherwise deficient. They lack essential details on priorities for booming of sensitive areas and on the installation of booms at individual sites. Information on the location of on-site and off-site equipment and supplies and on availability of contractors was sketchy and out-of-date. Specific guidelines and parameters for the use of burning in place, dispersants and other chemical treatments were not provided. Responsibilities and objectives for the protection, rescue and rehabilitation of wildlife are vague and sometimes contradictory. In a spill of this magnitude, which required the involvement and coordination of a number of federal and state agencies, oil companies and other private organizations, the inadequacies of the plans became obstacles to prompt, efficient response actions. This was further exacerbated by the spill response organization, which was directed by a triumvirate including Exxon Corporation, Alaska Department of Environmental Conservation and the Coast Guard's Federal On-Scene Coordinator.

Alyseka is to make the first response to any spills from the pipeline, the terminal and from tankers sailing between the terminal and Hinchinbrook Entrance. In monitoring of drills and response to small spills prior to the *Exxon Valdez* spill, the Environmental Protection Agency and the Coast Guard noted a number of deficiencies in Alyeska's ability to promptly and adequately implement their plan.

The Coast Guard started the response by a call to Alyeska. Some of their spill response equipment was down for repairs and there was also difficulty in locating and loading equipment. As a result the initial response appears to have been delayed approximately 10 hours. The capacity of skimming equipment dispatched to the scene fell far short of that needed, considering the magnitude of the spill.

Exxon started preparations for lightering the remaining oil from the tanker on the morning of March 24. After some early difficulty in locating the necessary equipment, lightering began on the morning of March 25. Lightering operations were successful and prevented the possible spilling of an additional 42,000,000 gallons of oil.

Exxon accepted responsibility for the spill and began the formidable task of assembling the equipment and personnel necessary to conduct containment and cleanup operations. Logistics of accomplishing this were hampered by the lack of a comprehensive inventory of cleanup equipment and skills. In spite of this the company was able to amass an impressive array of equipment.

Early efforts in cleanup were concentrated on removing oil from the surface of the water. Use of dispersants and burning were considered, but implementation was delayed by lack of pre-planning, and these two techniques were never effectively employed. Skimming operations were implemented as soon as equipment became available, but were not adequate to prevent oil from reaching the shore.

Efforts to exclude oil from some biologically sensitive areas such as fish hatcheries and spawning areas were somewhat successful; however there was not enough equipment to protect all these areas.

Beach cleanup began in late April and continued through September. A number of techniques were employed with limited success. Although some oil was removed, a considerable amount remains in the substrate, especially in protected areas. Locations where more cleanup is needed are currently being identified, and operations are to start May 1, 1990.

Effects

The Prudoe Bay crude spilled from the *Exxon Valdez* is rich in volatile hydrocarbons such as benzene and toluene, the most toxic parts of the oil. The majority of these gasses evaporated quickly and entered the air column within the first few days of the spill. The remaining oil that was exposed to wave action gradually became a thick, sticky, brown colored emulsion of oil and water referred to as mousse. Unlike the liquid oil deposited on the shore early in the spill, mousse did not penetrate deeply into the substrate, but did cling tenaciously to anything it contacted.

Many miles of shoreline impacted by the oil are gravel and rocky substrates that allow maximum penetration. On some of these substrates oil has penetrated 28 inches in depth. The large number of inlets and coves act as traps and protect the oil from high energy wave action with might help to break it up and remove it. Subarctic temperatures tend to slow the weathering of oil and degradation by normal processes. For these reasons oil may remain in the environment for some time to come, resulting in long lasting effects.

Direct contact with volatile gasses and oil fatally injured a large number of birds and sea otters early in the spill. By August 1, approximately 30,000 dead birds comprised of 90 species had been recovered, including 144 bald eagles. Approximately 1,016 dead sea otters have been recovered to date. In all probability many more birds and sea otters were killed but not recovered. Effects on other animals, including pinnipeds, cetaceans, terrestrial mammals and fish are less apparent and are being studied as are the more subtle long term impacts on populations from adverse effects on reproductive capacity.

There may be an adverse effect on the long term recovery of animal populations due to loss of key plant and animal species lower in the food chain and other factors contributing to ecosystem imbalance. These relationships are of particular concern in intertidal and immediately adjacent supratidal and subtidal ecosystems that are habitat for a large number of species.

While there have been obvious effects on wildlife from oiling and cleanup activities, there have also been subtle but potentially significant effects on other resources and values. One of the objectives of national forest wilderness study areas, national parks and wildlife refuges is to retain their natural, pristine character for a variety of reasons, including research and public enjoyment. Where the shores of these areas have been oiled and cleaned, there has been an adverse effect on their pristine character and a resultant loss in value for research and other purposes.

Tourism and recreation have increased significantly in the area of the spill in the last few years. The spill is most likely to have an adverse effect on those forms of recreation and tourism that involve an intimate relationship with wildlife or areas, such as beaches and coves, that have been impacted by oil. Kayaking, small boating, sport fishing and hunting, as well as wildlife viewing as activities that may have been adversely affected, especially in Prince William Sound.

The Alaska Heritage Resources Survey has documented 460 prehistoric and 140 historic sites along the oil-impacted shore. These known sites likely constitute less than 10 percent of the actual sites present in those areas. Many of these archeological sites are in intertidal areas, especially in the Sound, due to subsidence in the 1964 earthquake.

Oiling may interfere with the traditional cultural value of sites for Native Alaskans and with traditional carbon dating techniques. There is one recorded incident of vandalism of an archeological site by a member of a cleanup crew. As more sites are discovered, there is the potential for increased vandalism.

Subsistence is a way of life for inhabitants of many small villages; they rely on fish, wildlife and other resources close to their villages for their existence. If the availability of these resources has been significantly reduced, there could be a serious effect on inhabitants of these villages.

Finally, there are physical impacts on uplands from cleanup and study activities. Cleanup crews have trampled areas of vegetation adjacent to cleanup sites on islands within the wilderness study area on the Chugach National Forest. A number of administrative sites have been established in support of response activities, including electronics sites, weather stations, camps and water transmission lines.

Injury and damage to resources are being assessed in a number of studies that are documented in the "State/Federal Natural Resource Damage Assessment Plan and Restoration Strategy for the Exxon Valdez Oil Spill" dated August 1989.

Lessons Learned

The most important lesson to be learned is the need for eternal vigilance. The success in moving almost 9,000 loaded tankers through the Sound without a serious spill resulted in people dropping their guard.

Prevention is the first priority, and reviews to date have recommended consideration of a number of preventive measures. These include reconsideration of double hull construction for tankers. Tighter traffic control was instituted immediately after the accident and remains in effect. Tenders accompany each tanker from Port Valdez to Hinchinbrook Entrance. Also, more attention should be given to the size, skill level and physical condition of crews operating tankers.

It is necessary to review contingency plans to assure their adequacy and the proper meshing of tiered plans. They need to be updated regularly to assure current inventories of equipment, supplies and skills. Inventories should include local, regional, national and international resources. Pre-positioning of equipment in strategic locations should be considered. Baseline surveys of key resources that would be in the path of an oil spill should also be conducted as a part of contingency planning. Baseline information was not available for many key wildlife species.

An oil spill of this magnitude is a massive organizational challenge, and there is a need for improvement in the organizational structure. Roles need to be defined better, and the chain of command clarified. Perhaps an organization patterned after the incident command system that has been used so successfully in managing wildfires should be considered. Finally, research and development is necessary to acquire new technology for cleanup of an oil spill. Current equipment and techniques are inadequate.

The Exxon Valdez Wildlife Rescue and Rehabilitation Program

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Introduction

This paper summarizes the organization and operation of the avian and sea otter rescue and rehabilitation programs associated with the Exxon Valdez oil spill during the spring and summer of 1989. These programs were the largest and most comprehensive effort of their kind ever attempted. Included are a short chronology of the rescue programs of both Prince William Sound (PWS) and the Gulf of Alaska (GOA) and a description of the rehabilitation program. Details of the relative success rates of the programs and evaluations of rehabilitated animals are included to document the lessons learned from the rescue programs.

Bird Rescue Program

On March 24, 1989, the day the oil spill occurred, the International Bird Rescue Research Center (IBRRC) was contacted to organize a bird rescue/rehabilitation program in Valdez. Upon arrival, the group met with Exxon staff and located a suitable facility to serve as the bird rehabilitation center. The facility opened on March 31, 1989.

The IBRRC of Berkeley, California has been under contract with Alyeska since 1975 to respond in the event of an oil spill. The organization was founded by Alice Berkner in 1971 in response to an oil spill in the San Francisco Bay area. Current methodology is published in two books produced by the American Petroleum Institute and written by IBRRC staff. They are *Saving Oiled Seabirds* (1978) and *Rehabilitating Oiled Seabirds: A Field Manual* (1985).

While operations actively continued in Valdez, the IBRRC began to set up additional bird centers in Seward and Kodiak in mid-April. An additional holding facility in Homer was established by local residents, with IBRRC serving in an advisory role.

Throughout the summer Seward became the central rehabilitation facility as the other centers were closed because of declining activity. In early July, the Kodiak center was closed and arrangements were made with a local veterinarian to hold captured birds until they could be sent to Seward for full treatment. In late July, with concurrence from the USFWS, the Homer facility was closed along with the Valdez center. Final closure of the Seward center occurred September 20, which can be considered the date the bird rehabilitation program terminated.

Search and Rescue Operations

In most previous spills, volunteers walked the coastlines in search of stranded oiled birds, captured them, and drove to the oiled bird center. However, in the remoteness of Prince William Sound (PWS) and Gulf of Alaska (GOA) this type of operation was not feasible. The use of boats was necessary to retrieve oiled birds.

Throughout the program a total of 143 boats were used though not all were used any one time. Figure 1 depicts boat usage during the course of the bird rescue effort. As the graphs show, rescue operations in both PWS and Seward peaked in late April and into early May while operations in Homer and Kodiak peaked around mid-May.

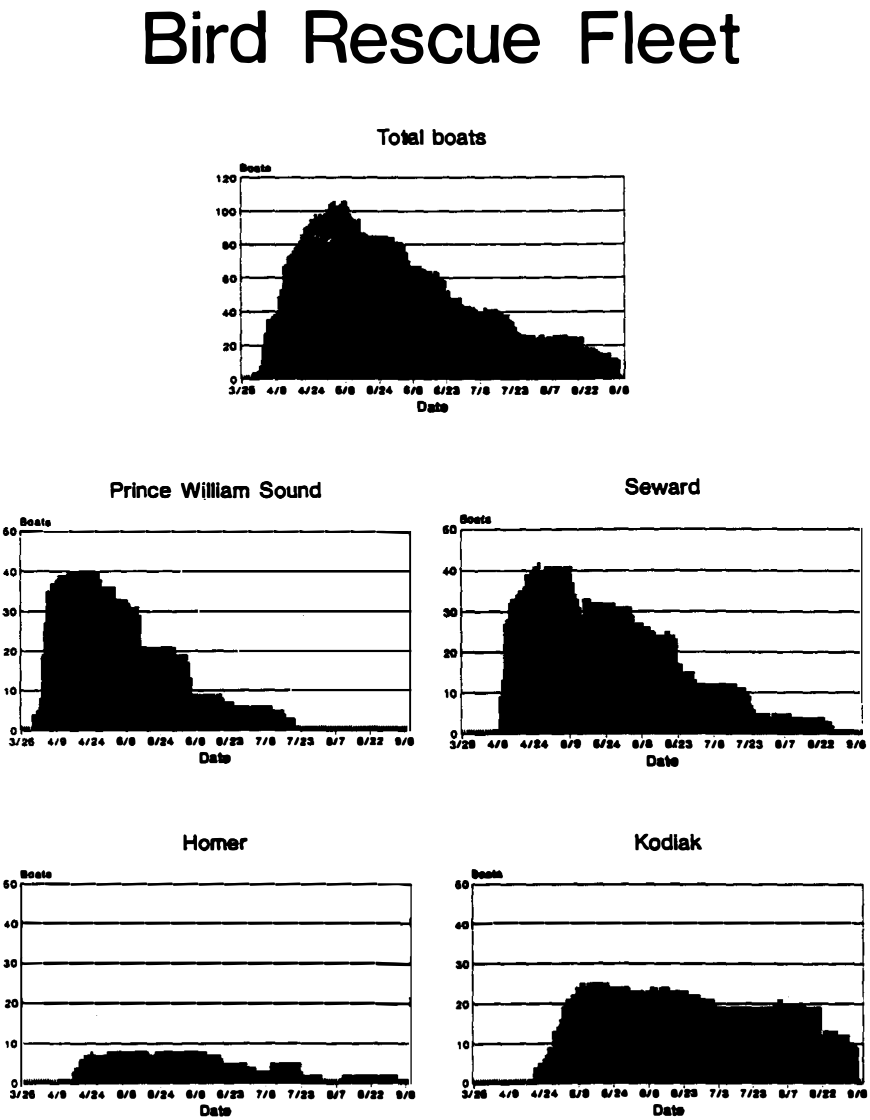

Figure 1. A summary of bird-rescue boat activity and bird recovery data.

Achievements and Lessons Learned

- Due to the magnitude of this spill, IBRRC operated and coordinated activities of bird centers in four work sites (Valdez, Kodiak, Homer, and Seward) separated by hundreds of miles. More personnel were required than ever before due to the number of centers and because of the extensive search and rescue programs. At one point, some 400 personnel were being managed and coordinated through IBRRC and Exxon.
- The bird rescue program also interfaced with the Exxon Bald Eagle Program and evaluated cases referred in from the field program. IBRRC handled the short-term rehabilitation cases and referred long-term cases to Dr. Scott in Anchorage. Of the 39 bald eagles referred in for further rehabilitation, IBRRC was able to return 11 to the wild in about two weeks.
- In this spill, IBRRC was able to collect blood for analysis from more species than ever before. They coordinated the field hematology with the University of Minnesota for serum chemistry results on 137 bald eagles caught as a part of the Exxon Bald Eagle Program. Over all, 259 serum chemistries on 25 species of birds were collected. The information gleaned from these tests was used during the program as one of many criteria in evaluating readiness for release and will be further analyzed in the future.
- New treatments were attempted to reduce the amount of time that severely affected birds spent in captivity and to increase the survival and release rates for birds. Some of these new treatments worked well and will be utilized in the future to improve the efficiency of bird rehabilitation.
- More necropsies were performed here than at any previous spill and more histopathology was done on those birds from which samples were taken. Some were performed by IBRRC staff, others by the Armed Forces Institute of Pathology (AFIP). This should increase the amount of information available regarding the effects of oil on birds. Incidentally, new parasites or other health problems may also be noticed and added to the literature.
- The overall effort here was a very good one. Some 71 species of birds were handled during the six month long program (Table 1). Over 1,600 birds were brought in live for treatment. The release rate for the seabirds was 50 percent, which is excellent given the time of year of the spill, the climate, the remoteness of the site and the logistics for bird salvage attempts (Figure 2).

Sea Otter Rescue

On March 25, the U.S. Department of the Interior and Exxon contacted Drs. R. Davis and T. Williams at the Sea World Research Institute in San Diego and requested their assistance in establishing a sea otter rescue program in Valdez. Davis and Williams had developed the techniques to clean and rehabilitate oiled sea otters during a study for the Minerals Management Service in 1984 (Sea Otter Oil Spill Mitigation Study, MMS-86-0009).

Valdez

Marine mammal specialists throughout North America were contacted by telephone and asked to assist in the rescue effort. At the same time, volunteers were recruited

Table 1. 1989 bird dispositions by species.

Species	Died	Euthanized	Released	Total
Aleutian Tern	1			1
Ancient Murrelet	13			13
Arctic Loon	5	4	6	15
Arctic Tern		1		1
Bald Eagle	2		16	18
Barrow's Goldeneye	6		7	13
Black Scoter	5	1	2	8
Black-legged Kittiwake	38	4	33	75
Bufflehead	3			3
Canada Goose			1	1
Cassin's Auklet	6			6
Cliff Swallow	6	1	3	10
Common Eider			1	1
Common Goldeneye	3	4	4	11
Common Loon	12	5	5	22
Common Merganser			6	6
Common Murre	123	60	348	531
Common Raven	1		2	3
Crow	1	1	1	3
Double-crested Cormorant			1	1
Eared Grebe			1	1
Fork-tailed Storm-Petrel	13		9	22
Fox Sparrow			2	2
Franklin's Gull			1	1
Gadwall			3	3
Glaucous-winged Gull	7	26	39	72
Greater Scaup	5		19	24
Green-winged Teal	1			1
Harlequin Duck	18	1	23	42
Herring Gull		1	1	2
Horned Grebe	10			10
Horned Puffin	17	1	34	52
Kittlitz's Murrelet	4		2	6
Leach's Storm Petrel	1			1
Lesser Canada Goose		1	1	2
Lesser Scaup			2	2
Lincoln Sparrow			1	1
Mallard		1		1
Marbled Murrelet	28	2	3	33
Mew Gull		1	1	2
Northern Fulmar	6	2	15	23
Northern Phalarope			1	1
Northern Pintail	1			1
Northwestern Crow	1	1	2	4
Oldsquaw	4		1	5
Orange-crowned Warbler			1	1
Parakeet Auklet			2	2

(continued)

Table 1. *Continued*

Species	Died	Euthanized	Released	Total
Parasitic Jaeger			1	1
Pelagic Cormorant	77	5	33	115
Pigeon Guillemot	87	11	29	118
Red-breasted Merganser	1	3	1	5
Red-faced Cormorant	8	2	1	11
Red-necked Grebe	13	2	2	17
Red-necked Phalarope	2		1	3
Red-throated Loon			1	1
Rhinoceros Auklet			6	6
Robin	1			1
Semipalmated Plover	1			1
Short-tailed Shearwater	77	5	25	107
Sooty Shearwater	4	2	12	18
Stellar's Jay			1	1
Surf Scoter	3	1	2	6
Thick-billed Murre	1	1	8	10
Tufted Puffin	20	2	64	86
Violet-green Swallow	1			1
Western Sandpiper	1		2	3
White-winged Crossbill			1	1
White-winged Scoter	4	9	20	33
Total	642	161	801	1604

to help with construction of the rehabilitation facility. Beginning with these individuals, the staff eventually grew to over 250 specialists and volunteers.

On March 30, the first oiled sea otter was received from Smith Island. Two days later, 18 otters arrived, the maximum number that were received during a single day (Figure 3). Oiled sea otters continued to arrive at an average of 10 per day until April 9, after which the new arrivals averaged only 1 to 2 per day until May 6. The gymnasium at the Growden-Harrison Complex, which could accommodate pens for 120 otters, was chosen for an expanded sea otter rescue center on April 2.

Seward

The Seward facility consisted of 10 ATCO trailers, 24 pens and 6 pools. Seventeen oiled sea otters were captured from May 1–4 and were temporarily held in cages at the Seward Bird Rescue Center until the otter facility was opened on May 5. On May 17, 21 otters were transferred to the Valdez otter center and the temporary facility at the bird center was closed (Table 2).

On May 10, the Kenai Peninsula Borough and Exxon began providing financial support for the pre-release facility at Little Jakolof Cove near Homer. The primary purpose of this facility was to hold rehabilitated otters from the Seward otter center until the USFWS completed a release plan for the Kenai Peninsula.

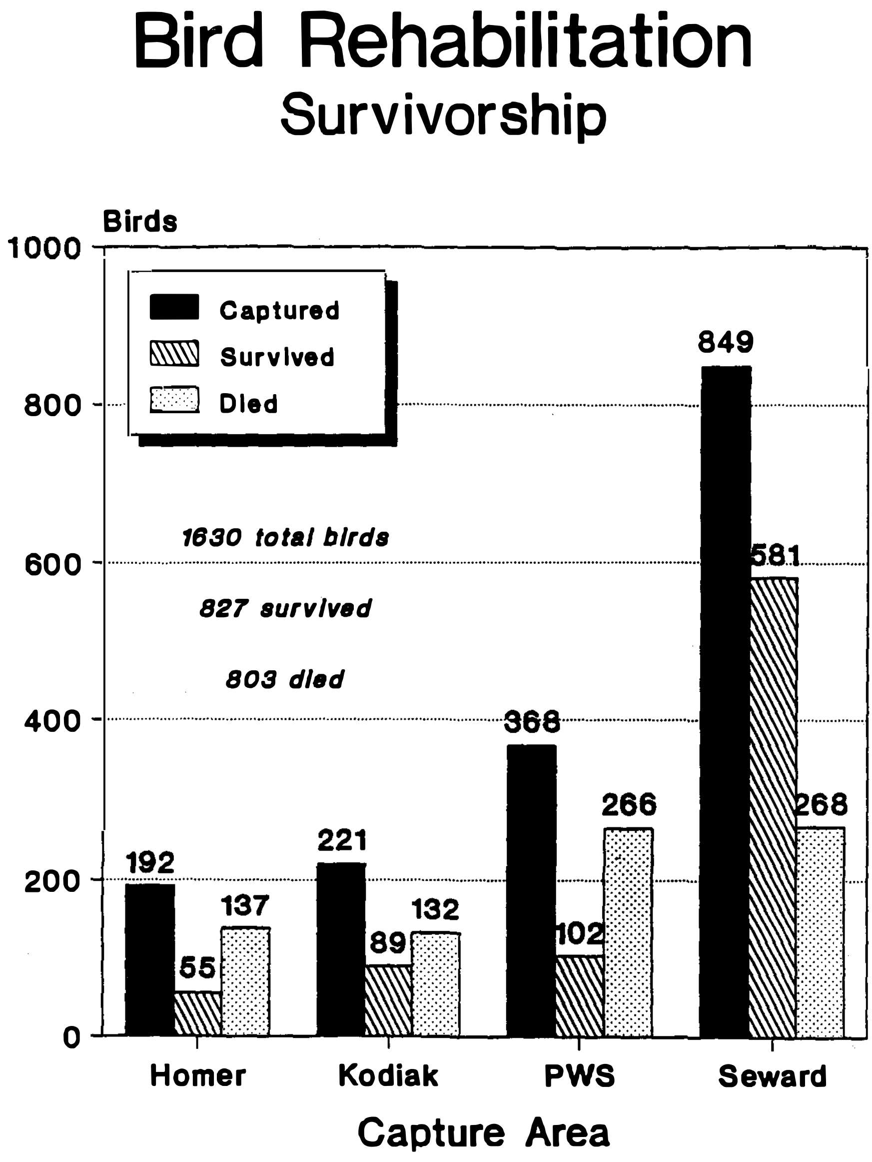

Figure 2. Bird rehabilitation and survivorship data for the four bird centers.

Sea Otter Release

On May 15, the first seven rehabilitated sea otters from the Valdez otter center were released by the USFWS in Simpson Bay, Prince William Sound (Table 2). These otters had small radio transmitters attached to their hind flippers so that they

COMPARISON OF OTTER NUMBERS

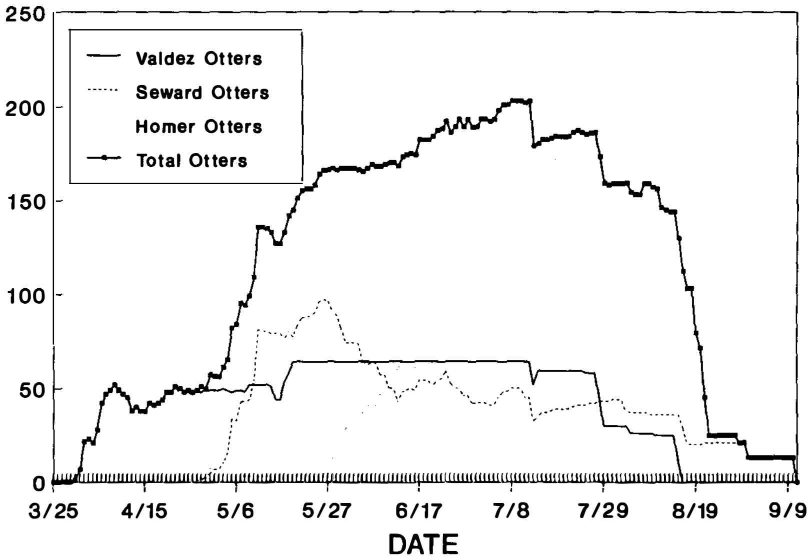

Figure 3. Sea otter recovery and release data for the three otter facilities.

could be tracked for several weeks. In general, the release plan called for otters captured in Prince William Sound to be released in the eastern (unoiled) part of the Sound, and otters captured along the Kenai Peninsula and in Kodiak to be released in unoiled areas of the Kenai Peninsula. The release plan also stipulated that up to 60 otters would have radio transmitters implanted in their abdomens and be released in Prince William Sound so that they could be tracked for 1–2 years.

Achievements and Lessons Learned

- Oiled sea otters were cleaned using methods modified from Williams et al. 91988) and Davis et al. (1988). In these studies the oiled animals were sedated before cleaning. During the spill, it was found that heavily oiled sea otters were often unsuitable candidates for sedation because they were lethargic, hypothermic or displayed respiratory distress. Instead, they were physically restrained during cleaning.
- One result of the vigorous washing and rinsing was depletion of natural oils from the fur and possibly the skin (Davis et al. 1988). Therefore, the fur of sea otters washed in the rescue centers became very hydrophilic and retained moisture, especially next to the skin where it is least exposed to evaporative forces. The strong hydrophilicity of the fur delayed the ability of the otter to re-establish the insulating air layer next to the skin. Consequently, many of the animals had

Table 2. Sea otter counts for the Valdez, Seward and Homer centers.

	Homer	Seward	Valdez	Total
Total animals w# (adults and pups)	14	187	156	358
Recovered from wild	17	168	149	334
Rogues captured	5	0	1	6
Live births	4	12	2	18
Transfer in				
from Kodiak		(information not available)		
Homer	na	8	4	12
Seward	99	na	21sw#	120
Valdez	0	0	na	0
Transfer out				
To aquariums	0	13	24	37
Escaped Valdez H.	0	0	10	10
Released				
PWS	21	7	60	88
Kenai	58	11	0	69
Homer "soft" + escape	31	0	0	31
Died (adults and pups)	3	38*	85	126
Pups dead	1	8	2	11

Notes:
358 total animal into center.
18 pups born.
11 pups dead.
224 released or alive in center 9/15/89 + 10 escaped.
3 pups subsequently died in Pt. Defiance.
2 known released dead in PWS.
1 known released dead in Kenai.
1 animal to Seward from Homer, 2 animals to Valdez from Homer that never received Homer #.
*Includes animal with SW# that died during anesthesia in Homer.

to be held in dry cages for prolonged periods until they were able to groom themselves.

- To return natural oils to the fur and quicken the return of water repellency, Redkin Laboratories developed a product that could be applied to the otter's fur after cleaning and rinsing. This product was designed to provide a very thin coating of artificial sebum (squalane) to the skin and fur.
- Several important areas of research became apparent while treating sea otters impacted by the oil spill. The most important of these is the short and long term toxicological effects of petroleum hydrocarbons on sea otters. A standardized test for quickly assessing petroleum hydrocarbons in blood samples will help differentiate between internal and external crude oil exposure. These data will be especially important for developing treatments for animals in rehabilitation centers.

Table 3. Chronology of releases and the release locations for sea otters at the rescue centers at Valdez, Seward and Homer.

Date	Number of Otters	Location Released
4/02/89	1	Seaworld[a,d]
4/12/89	4	Pt. Defiance Zoo[a,e]
4/13/89	2	Monteray Bay AQ[a]
4/17/89	4	Vancouver AQ[a,f]
4/24/89	1	Valdez Bay[a]
5/16/89	7	Simpson Bay[a]
5/19/89	1	Valdez Bay[a]
6/12/89	1	Little Jakalof[c]
6/17/89	1	Little Jakalof[c]
7/13/89	7	Valdez Bay[a]
7/14/89	8	Little Jakalof[c]
7/25/89	1	Valdez Bay[a]
7/27/89	13	Sheep Bay[a]
7/28/89	1	Herring Island[c]
7/28/89	15	NF, Nelston Bay[a]
8/04/89	4	Seaworld[a]
8/05/89	1	Little Jakalof[c]
8/11/89	10	Little Jakalof[c]
8/12/89	1	Little Jakalof[c]
8/13/89	1	Little Jakalof[c]
8/15/89	6	Nelson Bay[a]
8/16/89	8	Sheep Bay[a]
8/16/89	3	Nelson Bay[a]
8/16/89	7	Nelson Bay[2]
8/17/89	7	Taylor Bay[b]
8/17/89	1	Picnic Bay[b]
8/19/89	7	North Arm Nuka Bay[c]
8/19/89	16	James Lagoon, McCarty Fiord[c]
8/20/89	8	James Lagoon, McCarty Fiord[c]
8/21/89	25	Harris Bay[c]
8/21/89	2	Herring Islands[c]
8/22/89	18	South Shore, Sheep Bay[c]
8/22/89	3	Nelson Bay[c]
8/30/89	4	Little Jakalof[b]
9/11/89	13	Pt. Defiance Zoo[b]
Total	224	

[a]Released from Valdez Center.
[b]Released from Seward.
[c]Released from Homer Center.
[d]Does not include 4 otters that died in captivity.
[e]Does not include 2 otters that died in captivity.
[f]Does not include 2 otters that died in captivity.

The Wreck of the Exxon Valdez

Bruce H. Baker
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Juneau

As a nation we make up only 4.7 percent of the world's population, yet we account for 26 percent of the world's consumption of oil. The Alyeska pipeline and its Valdez terminal supply 25 percent of the oil our nation consumes. The principal point I'd like to make is that for America's fish and wildlife to be protected, it's imperative that the oil industry be required to internalize the costs of oil spill safeguards in calculating their bottom line.

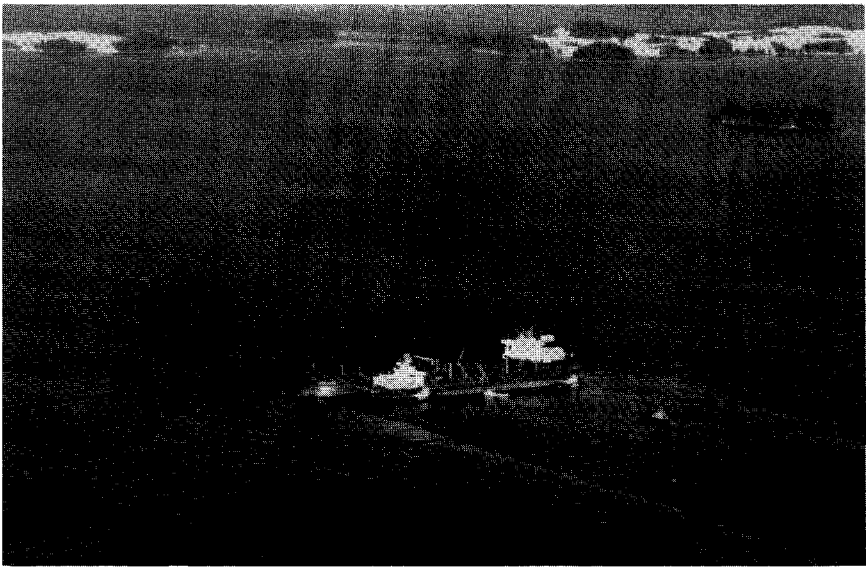
Weather conditions at the time of the March 24, 1989 grounding of the *Exxon Valdez* were ideal by Alaska standards. Seas were fairly calm, temperatures were mild, and day length was favorable. It's fortunate that the disaster did not occur in the long, subzero darkness of a North Pacific winter storm. After the vessel ground to a halt at midnight, it was gushing oil at the rate of 20,000 barrels an hour. Eventually, more than 257,000 barrels spewed into what had been one of the most pristine, biologically productive and environmentally sensitive marine ecosystems in the world. According to a February estimate 20–40 percent of the oil has evaporated, only 5–14 percent has been recovered, and 56–65 percent remains unrecovered. The combination of low oil recovery under highly favorable weather conditions shattered the assurance long fostered by the oil industry that spills can be contained and cleaned up year-round in open seas or in pack ice.

Resources at Stake

The biological resources at stake in Prince William Sound included all five of Alaska's salmon species as well as halibut, shrimp, cod and shellfish. In 1988, the value of commercial fisheries in the sound to fishermen totalled more than $110 million. That does not include the value added through primary processing and other economic multiplier factors. In an average year, the Prince William Sound hatcheries provide upwards of 40 percent of the salmon harvest in the sound and in 1988, because of low natural runs of pink salmon, they contributed an estimated 90 percent of the sound's total salmon harvest. More than 600 million juvenile fish were scheduled for release in 1989 from these hatcheries.

In addition to its world-class fisheries, the area is well known for its abundant marine mammal and bird populations, and the opportunity to view them is an important attraction. Many of these species have been at risk. Through contact, ingestion or inhalation, the toxic components of oil may cause death or sublethal effects in marine mammals. Never before has so much important marine mammal habitat been so heavily oiled.

The long-term recovery of sea otter populations following their near extinction in the 1700s is a biological success story and, at the time of the spill, an estimated 5,000–10,000 lived in Prince William Sound; perhaps 2,000–3,000 lived within the portion of the sound impacted by the spill.



The single-hull supertanker, *Exxon Valdez*, aground on Bligh Reef in Alaska's Prince William Sound. Alaska Dept. of Fish and Game photo.

From a biological standpoint, the spill could not have happened at a worse time of year. Marine mammals were about to have their pups, humpback whales were returning to the sound to feed and bird populations were reaching yearly peaks. More than 300,000 birds were in the sound at the time of the spill, with approximately 200,000 more expected to return for the summer. Soon after the spill, over one million waterfowl and ten million shorebirds passed through the area on their way north. In addition, black bears, Alaska brown bears, black-tailed deer and bald eagles were on hand to scavenge or forage along oiled shorelines.

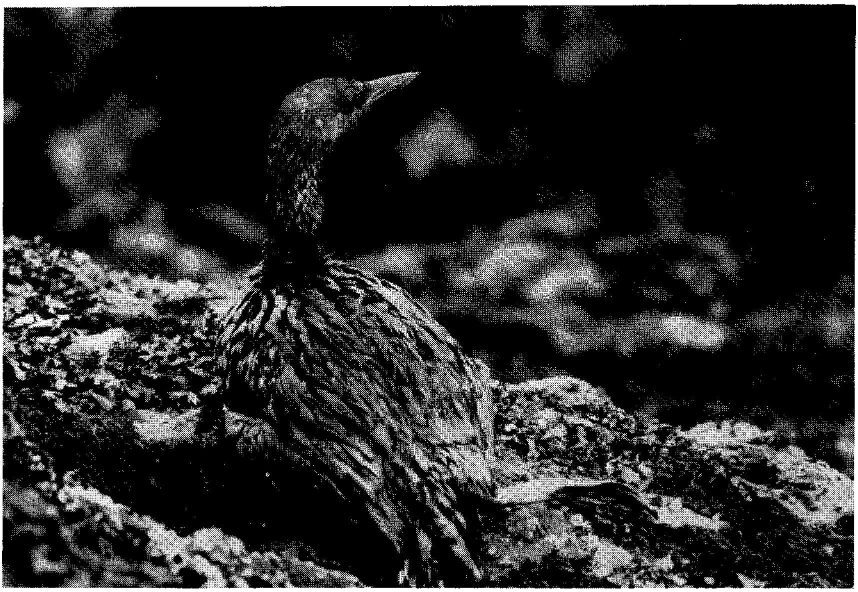
By mid-May, the oil had followed predictable ocean currents out of Prince William Sound into the Gulf of Alaska, where it proceeded along the southern shores of the Kenai Peninsula, into the mouth of Cook Inlet and through Shelikof Strait north of Kodiak Island and along the Alaska Peninsula. By August, the spill had moved across nearly 10,000 square miles of water in Prince William Sound and the Gulf of Alaska, and more than 1,200 miles of shoreline had been oiled. Superimposed on a map of the East Coast, the spill extends from Massachusetts to a point well along the North

Carolina coast. The spill had moved more than 550 miles and had travelled as much as 17.5 miles per day. By August 23, oil had penetrated over two feet deep on some beaches and continued to bleed into open water, causing sheens. Fresh tarballs had begun to wash up regularly onto previously treated or uncontaminated beaches.

The path of the spill beyond Prince William Sound was heavily populated with many of the fish and wildlife that I've mentioned. The value of salmon fisheries beyond Prince William Sound to fishermen was $330 million in 1988. The comparable value of groundfish and shellfish fisheries of the western and southcentral Gulf of Alaska and Bering Sea in 1988 was at least $600 million. In the Kodiak area alone, 51 of 52 commercial salmon fishery districts remained closed last season because of the oil spill. Although there were record salmon returns last summer and fall in the Bering Sea and Gulf of Alaska, these fish had outmigrated to sea long before the 1989 oil spill, and the assessment of the spill on fish populations is an ongoing one.

As the spill moved southwest, it has also passed through migration routes of gray whales and northern fur seals on their way to the Bering Sea.

By October 17, the U.S. Fish and Wildlife Service reported that the total number of confirmed dead birds attributable to the overall spill was 36,466. Their records indicate that 1,015 sea otters and 162 bald eagles and other raptors were killed. These numbers, as they have grown, must be understood in context. Because of the broad area affected by the spill, the rugged terrain, foul weather, and strong ocean currents, the vast majority of dead animals are not recovered. Their bodies sink, are washed away by currents, are scavenged or are hidden away in wooded areas where some crawl away to die.



Oiled loon in Alaska's Prince William Sound following the grounding of the *Exxon Valdez*. Alaska Dept. of Fish and Game photo.

Exxon did establish bird and otter rehabilitation centers in communities adjacent to the spill, and although the numbers of animals processed through such facilities are an extremely small percentage of the total number affected, there were often more volunteers for work in these centers than there was room for.

Assessing the Impacts

It may take up to five years or more before the millions of dollars worth of impact assessment studies that are being conducted will help piece together the total biological and economic impacts of this spill.

We do know that significant costs have already been realized by the hundreds of fishermen and support businesses that have been impacted by the closure of economically important fisheries because of contamination. It will also be years before we know just how long oil residues on shorelines persist and remain toxic. Sheltered, low-energy shores are not subject to the kind of wave action that occurs along exposed coasts, and oil is expected to persist longer there. The state's goals in conducting an assessment are threefold: (1) to measure the extent of the injury to our resources, (2) to assess that impact in a way that allows the state to be fully compensated by the responsible parties and (3) to determine how restoration of the resources can be assured.

The state has joined with three federal, co-trustee agencies in developing a State/Federal Natural Resource Damage Assessment Plan for the spill. The plan has been prepared in accordance with federal law (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]). The assessment studies described in the plan have been expected to cost $35 million through February 1990 alone, and they fall into a number of categories: coastal habitat, air and water, fish and shellfish, marine mammals, terrestrial mammals, birds, economic uses and restoration.

When the assessment is completed, a claim will be presented to the potentially responsible parties. The claim will include both damages and any unreimbursed cost of the assessment. Damages collected will be used to restore, replace or acquire the equivalent of the injured natural resources.

Unfortunately, we have encountered several problems with the federal laws and regulations that relate to oil spill assessment. As we have explained to Congress, the problems are associated with the prescribed valuation methodology, the lack of organizational structure for managing the actual natural resource impact assessment and the lack of identified funding sources.

A recent decision by the U.S. Court of Appeals addressed the valuation methodology prescribed by the federal regulations and criticized these aspects of the regulations as too limited. The court directed the Department of Interior to draft new regulations that would allow recovery of the costs of restoring damaged areas and wildlife, unless those costs are "grossly disproportionate" to the value of the injured resources. (The court rejected the lesser of diminution in value or restoration rule.)

The court also criticized the regulations for not including nonconsumptive or passive use values, such as option or existence values, in its preferred methodology. Although these values are more difficult to calculate than, for example, the value of a seal pelt, the court recognized that they are legitimate values.

The assessment process is hampered by the lack of experience courts and economists have in valuing resources with no established market, such as wilderness areas generally. Economists recognize the unique values of areas such as Prince William Sound before the oil spill, but have no easy or widely accepted way to place a dollar amount on all of those values.

The state's second concern with the federal assessment regulations is that they do not provide a clear process for a state to assert leadership in completing the damage assessment of its resources. There are at least twelve separate state and federal agencies involved in the Exxon Valdez assessment, and it is our experience that a clearer definition of the state's leadership role is needed.

A third concern over these regulations is the lack of a mechanism for requiring the responsible parties to fund assessment studies up front, or of an identified fund to pay for all the necessary studies until such time as costs can be recovered from responsible parties.

Prevention, Containment and Cleanup

The efficiency of containment and cleanup has been a subject of the State of Alaska's testimony before Congress. For the state, the Department of Environmental Conservation is responsible for oil spill response regulation. That Department's commissioner, Dennis Kelso, has described industry's initial response to the *Exxon Valdez* spill as "inadequate, untimely and unacceptable." Commissioner Kelso testified before Congress that "The industry's response during the first critical 72 hours of the spill was ineffective, in part because of Alyeska Pipeline Service Company's decade-long efforts to scuttle any meaningful oil spill contingency plan."

In 1982, the company considered a 74,000-barrel spill the maximum probable spill. Then in 1986, their response to the state's insistence that the company plan for a spill of 200,000 barrels was that "Alyeska believes it is highly unlikely a spill of this magnitude would occur. Catastrophic events," they said, "are further reduced because the majority of the tankers are of American registry and all of these are piloted by licensed masters or pilots. . . ."

As Commissioner Kelso pointed out, "They didn't have enough booms, skimmers or collection barges. They didn't move quickly enough during the first three days when the seas were nearly flat. They didn't think big enough, and they didn't deliver the results they had promised." In fairness, I must add that since the spill, Alyeska has revised its spill contingency plan, and the state is encouraged by that effort.

Unfortunately, Exxon's winter plan did not include a research and development plan for finding new techniques to remove and recover oil from the shoreline. To date, the hot water wash has been the only method utilized and shown by Exxon to be effective in removing oil from surface rocks. The state's monitoring programs and shoreline assessment studies indicate that this technique results in only limited penetration and oil removal from upper sediment layers and virtually no removal from deeper strata. It has been the state's belief that subsurface oil poses the greatest potential threat to the environment, and Corexit 9850, a kerosene-based, shoreline dispersant, appears to be effective only in removing oil from rock surfaces.

Bioremediation, the bacterial degradation of oil, has also been promoted as a solution to the problem of oil on shorelines. The state has been supportive of attempting this technique, but only as a final step after the majority of oil has been removed. At an EPA sponsored bioremediation workshop, participants were quite guarded in describing the merits of applying Inipol, a fertilizer formulation applied last summer on oiled shorelines. In the words of a state participant, "Inipol-treated plots looked good in pictures, but statistically (Inipol) did not remove more oil than at beaches treated with water soluble fertilizers or beaches which were not treated at all."

By August 23, the state concluded that no shoreline was considered to have received final treatment and that Exxon's mileage figures did not include any miles of cleaned shoreline. A detailed survey of shorelines affected by the spill was conducted by the state from August 24 to November 20. This survey revealed more than 117 miles of shoreline that had heavy to moderate oiling. Two hundred twenty four shoreline segments out a total of 886 segments surveyed had oil that penetrated at least 15 cm into the sediments. In 88 of the 224 segments, oil penetration was from 30–75 cm.

Oiled shoreline in Alaska's Prince William Sound following the March 24, 1989 grounding of the single-hull supertanker, *Exxon Valdez* and the discharge of 11 million gallons of North Slope crude oil—the largest oil spill in U.S. history. Alaska Dept. of Fish and Game photo.

Planning for the Future

The question facing all of us is what can be done in the future that we haven't been doing to prevent or deal with spills. A lot of recommendations are coming out of this experience and I'll try to summarize those that have been put forth by the State of Alaska.

Federal Legislation

The state has recommended to Congress that first, the Coast Guard should make a thorough review of tanker design, construction and operations so that human errors will not result in loss of a tanker or its cargo. Second, Coast Guard licensing requirements should be revised so that license holders are reexamined more frequently and information on drug and alcohol violations is available to prevent giving command of a supertanker to a person who could be incapacitated. Third, a thorough review should be made of Coast Guard radar and navigational systems throughout the nation so that shore-based radar is always available when a tanker is maneuvering in dangerous or sensitive waters.

The state has also recommended that Congress require all tankers to have equipment and trained personnel on board to deal with large spills the moment they happen, and that the National Oil Spill Contingency Plan be changed so that:

1. The Coast Guard is automatically put in charge of large spills, without waiting to see if the responsible party does an adequate job;
2. A world-wide computer inventory of spill equipment and experts is maintained, so that whatever is needed can be put on site without delay; and
3. Computerized data on geographical, meteorological and oceanographical characteristics of coastal areas are maintained, so equipment and personnel can quickly be sent to wherever they will do the most good.

The state has recommended that the entire structure of contingency planning be reexamined to make sure that the right equipment and personnel are always available at strategic locations throughout the country.

In the area of emergency funding, the state has suggested a comprehensive look at existing federal funds available for containment and cleanup, so they are funded at the level needed for a major catastrophe, and so that access is quick and efficient. We have also recommended the same sort of comprehensive look at the federal programs available for emergency aid to individuals. Finally, the state has suggested a comprehensive look at ways to ensure that all claims for damages by an oil spill will be paid by the responsible parties.

At least 19 oil spill bills have been introduced in the U.S. Congress. Alaska and other states would do well to work together in the review of these bills and to cooperatively support those which improve existing spill prevention, cleanup, assessment and compensation.

State Legislation

In addition to tracking federal legislation, the State of Alaska is taking steps of its own. By emergency order, it has tightened the conditions under which terminal and tanker activities at Valdez are conducted. The governor and the legislature approved a multi-million dollar cleanup appropriation. The state legislature has also considered a long list of spill bills, and seven have been signed into law. One bill (HB 68) makes it easier for the state to collect money from companies that spill oil or hazardous substances. It places responsibility for the costs of cleanup and damages on those who economically benefit from their commercial production. A second bill (SB 277) creates a seven-member commission to investigate the *Exxon Valdez* disaster and recommend changes needed to prevent a recurrence. A third bill (SB 271) increases civil fines for oil spills from $10 a gallon to as much as $50 a gallon in the case of gross negligence. It also raises the cap on fines from $100 million to $500 million.

Three additional bills that have been signed into law call for a new 5-cent-a-barrel tax that will maintain a $50 million Hazardous Substance Release Response Fund (SB 260), a new state capability for oil and hazardous substance response (SB 264) and a requirement that oil companies cannot deduct spill cleanup costs from their state production taxes (SB 299). A seventh bill that passed into law (SB 261) provides for the development and implementation of state and regional spill contingency plans.

There are a variety of other remedies that the State of Alaska is considering. One is the use of an Incident Command System (ICS) to provide the organizational framework for the state's overall spill response effort. ICS methods were developed to provide an efficient multidisciplinary command structure as a civilian alternative to military command. The ICS can be adapted specifically for use in responding to oil spills, and planning for its use can be accomplished prior to major spills. The State has also recognized the importance of a role for local officials and other residents in a spill response. Residents of areas affected by a spill often have local knowledge and specialized skills that may not be available from other sources.

Natural Resource Recovery Following the 1980 Mount St. Helens Eruption: Lessons in Ecological Resilience

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Nearly 10 years ago, on May 18, 1980, Mount St. Helens erupted, causing massive changes over an area of 150,000 acres (60,750 ha) of forest land in southwestern Washington state. A cloud of hot ash and gas with temperatures up to several hundred degrees Fahrenheit spread over the area, killing all above-ground plant and animal life. Large amounts of volcanic ash were deposited over the area at variable depths, their thickness related mainly to distance from the volcano's crater. Large amounts of this material eroded at the time of the eruption, filling small streams and contributing to debris flows which scoured stream channels. In some areas directly in the path of the lateral blast, and close to the mountain, vegetation as well as soil was blown away, exposing the underlying bedrock. An earthquake accompanying the eruption triggered a massive debris avalanche on the north face of the mountain, filling the Toutle River valley with debris deposits up to 600 feet (182 m) thick in headwater areas. High streamflows generated from melting snow and ice transported massive amounts of sediment and other debris downstream, causing flooding, destroying homes, roads, railroads and industrial facilities, filling stream channels and blocking ship traffic on the Columbia River at its confluence with the Cowlitz River.

In addition to the 57 human lives lost, fish and above-ground populations of wildlife were destroyed. The Washington Department of Wildlife estimated losses of black-tailed deer (*Odocoileus hemionus columbianus*) and Roosevelt elk (*Cervus elaphus roosevelti*), at 5,000 and 1,500 animals, respectively. Countless numbers of small mammals, birds, reptiles, amphibians and fish were also killed in the eruption. Of the 150,000 acres (60,750 ha) of forest destroyed, 68,000 acres (27,500 ha), located primarily in the northern and western portion of the blast zone, were owned by Weyerhaeuser Company. Forest conditions on this ownership at the time of the eruption were approximately equally divided into three age classes of forest: old-growth, managed stands 12–40 years old that had been silviculturally thinned and fertilized and forest plantations in the 0 to 12 year age class. Tree species present included primarily Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) at elevations below 3,000 feet (910 m), with Noble fir (*Abies procera*) and Pacific silver fir (*A. amabilis*) at elevations above 3,000 feet (910 m). Within this area, damage of a variety of forms occurred, including trees killed and left standing, trees broken off at varying distances from the ground and stands partially or completely blown down. Most of the observations reported in this paper were made in the northern and western portions of the blast zone.

A number of research efforts addressing questions of natural resource recovery got underway soon after the eruption. These studies provided direction to salvage and rehabilitation efforts as well as documentation of rates and levels of recovery of selected organisms and processes. This paper addresses factors relating to the recovery of the vegetation, wildlife and fisheries resources of the Mount St. Helens blast zone, in the context of reestablishment of Weyerhaeuser's commercial forests.

Erosion

Much of the initial resource damage associated with the eruption was related to erosion. Within the Toutle and Cowlitz river watersheds, erosion and transport of debris and ash were of great concern to downstream interests. Potential flooding and measures to prevent or minimize it were obviously related to future erosion patterns and how they might be influenced by log salvage operations. Collins and Dunne (1988) examined rates of hillslope ash erosion, and found that erosion rates declined rapidly with time and were strongly influenced by rates and degree of revegetation. Fiksdal (1982) examined the effects of disturbance due to salvage logging on erosion rates, noting substantial declines due to increased infiltration of water following the mixing of soil and ash by the logging. Results of these studies demonstrated the value of salvage operations in erosion control, helped allay concerns regarding logging-caused erosion and identified those situations where seeding of grass for erosion control would be of greatest value.

Revegetation

The drab gray scene presented by the blast area shortly after the eruption led some initial observers to suggest recovery of the vegetation would be a lengthy process. Actual observations of revegetation have shown surprisingly high rates, especially in the western portion of the blast zone. Stevens et al. (1987) measured 50 percent canopy cover on his sample areas in fall, 1980, and nearly 100 percent cover by summer, 1981. Since most of the initial vegetation came from shoots emerging from live root systems beneath the ash, the amount and type of vegetation existing on the site at time of eruption had a major effect on recovery patterns. This relationship was most obvious when areas in forest plantations greater than three years old at the time of the eruption were compared to those where site preparation had more recently occurred and herbaceous and shrub vegetation was less well developed. Another factor significantly affecting vegetative recovery was the amount of erosion occurring. Since the ash proved initially to be inhospitable to seed germination, eroded rills or gullies where the original soil surface was exposed were major sites of plant establishment. Similarly, where tractor scarification to prepare sites for tree planting removed the ash layer, wind-dispersed herbaceous species of vegetation were able to become established. This combination of processes led to the rapid development of a nearly complete cover of vegetation, with high levels of biomass, over all but areas of deep, undisturbed ash, throughout the northern portion of the blast zone.

Reforestation

The continued suitability of the Mount St. Helens blast zone for forest production was an early question for forest managers. To address this question, trials to determine survival and growth of forest seedlings began as early as June, 1980. As was observed with natural revegetation, the sterile nature of the ash made it necessary that the seedling roots be in contact with the parent soil (Winjum et al. 1986). Erosion of the ash layer and harmful puddling in the planting depression also occurred. To address these problems, tree planters were instructed to shovel away ash so that seedling roots were placed in mineral soil and to dig a channel so that drainage of surface water would occur. In areas of deepest ash, trials of various equipment to remove the ash layer led to the selection of a tractor-mounted V-blade plow as the most effective tool. Based on these early studies, a major operational planting program began, in 1981, to be completed over a 5-year period. This program was completed, on schedule, in 1986, with 18 million trees having been planted on 45,500 acres (18,950 ha) of Weyerhaeuser Company land. Of the remaining 23,000 acres (9,300 ha), two-thirds were traded to the USDA forest Service as part of the Mount St. Helens National Volcanic Monument. An additional 2,500 acres (1,000 ha) was recently acquired by the Rocky Mountain Elk Foundation and the Washington Department of Wildlife to be managed as an elk winter range and viewing area. The balance remains inundated with avalanche debris deposits and mudflows. Survival rates of planted trees are high, generally over 90 percent, and comparable to those observed in more normal regeneration areas. Growth rates are also high, with some indication that the ash covering may have provided a mulching effect, contributing to higher than normal growth rates. A developing forest is now in place, with some of the earliest-planted trees now exceeding 20 feet (6 m) in height.

Wildlife

As with projections about recovery of vegetation, estimates of the time required for wildlife recovery were varied, but generally pessimistic, and on the order of decades. Clearly the habitat and its associated wildlife populations had been devastated. Casual observations made in the first few days and months after the eruption indicated there were wildlife such as frogs and some small mammals that survived because they were underground. Carcasses of larger species such as elk and deer were observed; few traces of other species were seen. A wildlife survey of the northern blast zone, begun by Weyerhaeuser Company in 1981, provided an initial measure of the rapid rate at which wildlife were reoccupying that portion of the impacted area. By September of that year, some 90 species, two-thirds of which wre birds, had been observed. Species diversity was highest in summer, indicating breeding was taking place. Surveys continued for several more years, and showed that the range of species normally associated with early stages of forest development was present.

The wildlife species receiving the highest level of research attention was the Roosevelt elk. The Mount St. Helens area had historically supported heavily-hunted, productive elk populations which continued to be of high interest to hunters and the Washington Department of Wildlife. Elk damage to reforestation had long been a subject of concern to foresters. Thus several parties had an interest in the rate and patterns of elk population recovery. In addition, the extreme destruction of habitat by the eruption provided a unique opportunity to examine forest management–elk habitat relationships, including elk requirements for thermal cover, that were the subject of some debate at the time. As a result of this interest a 4-year cooperatively-funded study of elk population dynamics and habitat ecology was carried out by

Evelyn Merrill, a graduate student at the University of Washington, during the period 1982–86 (Merrill et al. 1987). Some of the key results of this study follow.

- Population recovery occurred rapidly, returning to pre-eruption levels within five years.
- Both immigration into the area and reproduction of resident animals were responsible for a rate of population increase approaching the maximum recorded for elk.
- Rapid population recovery was in part due to high availability of high quality forage.
- Elk used the blast zone on a year-around basis; the total absence of forest cover was apparently offset by an abundance of forage, limited human disturbance and elk behavioral modifications.

In the four years since the completion of Merrill's work, limited observations indicate the elk population increase has leveled off, apparently in response to reduced calf production. There have been no known instances of weather- or habitat-related elk mortality during this time.

Fisheries

Observing the post-eruption condition of streams and rivers in the Mount St. Helens blast area, predictions that as long as three decades would be required for recovery were made by some biologists. As with wildlife habitat, the blast zone was seen as a "worst-case" situation, and as such, provided a unique opportunity to examine fish population recovery. Beginning in 1983, a study to examine summer survival, production and habitat use of juvenile coho salmon (*Onchorhynchus kisutch*) was initiated by Weyerhaeuser Company in three volcano-impacted streams in the northern part of the blast zone (Bisson et al. 1988). These streams had experienced debris flows, heavy ash and sediment loading and complete loss of streamside vegetation. Key results of this work, which is continuing, follow.

- Stream temperatures have exceeded presumed lethal thresholds for salmon and trout in most years since the eruption.
- Habitat conditions were highly unfavorable as indicated by relatively little in-stream cover, infrequent pool habitat and an absence of riparian vegetation.
- Despite these adverse conditions, there have been no instances of temperature-related mortality. Coho salmon production rates at all sites were equal to or greater than those measured in other streams of comparable size in the Pacific Northwest.
- In the absence of competing species, coho salmon used a wider range of habitats than where other species are present.
- An abundance of both terrestrial and aquatic food was thought to be at least partly responsible for the high summer production of stocked juvenile coho salmon in what is considered a hostile environment.

On a larger scale, Lucas and Pointer (1987) compared density of spawning redds of steelhead (*Onchorhynchus mykiss*) in a number of rivers including several affected by the Mount St. Helens eruption, in southwest Washington. Redd densities of 34.6 per mile (21.5 per km) were observed in the south fork of the Toutle River, a stream that had experienced a substantial debris flow and high levels of sedimentation during the eruption. These spawning redd densities were the highest observed in any of the streams surveyed, including those in areas unaffected by the eruption. A possible reason for this observation is the restricted fishing seasons instituted after the eruption, which may have allowed increased spawner escapement.

Summary: Lessons from the Mount St. Helens Eruption

Key findings based on almost 10 years of research and management experience on Weyerhaeuser Company lands in the blast area include the following.

- A wide variety of interacting ecological processes can result in greater than expected resilience in natural systems. Examples include the positive influence of erosion of the ash layer in allowing vegetation establishment and the apparent enhancement of fish food levels as a result of stream channel exposure.
- Man's activities, both singly and in concert with natural processes can enhance rates of ecological recovery, as illustrated by the effects of soil disturbance and tree planting on erosion rates and vegetation establishment.
- Observations of the response of organisms to extreme habitat change contributes significantly to our understanding of those species' needs under more normal conditions. In the case of elk, patterns of habitat selection in response to local vegetation and weather conditions provided insights into what might be needed, in contrast to what is preferred, in the way of habitat features. Similarly, the apparent role of abundant food in offsetting the adverse metabolic effects of high temperature on coho salmon raises questions about the validity of standards derived from static laboratory tests.
- A catastrophe often facilitates making a change in man's normal activity patterns, which in turn allows an assessment of the effects of excluding man's role. In the absence of hunting, elk at Mount St. Helens seem to deal effectively with their environment, in spite of an absence of traditional forest cover. This observation suggests access control as a potentially effective management tool under some conditions. Likewise, the population response of steelhead, in part apparently due to a reduction in fishing pressure, strongly argues for management measures in addition to those related to habitat. Lacking an event like the Mount St. Helens eruption to facilitate making a major management change directed at the resource user, assessing the relative impact of all factors acting on a particular resource will be difficult.

The eruption of Mount St. Helens was, by all accounts, a natural resource disaster. At the same time it provided both a management challenge and a scientific opportunity. On Weyerhaeuser Company lands, the initial challenge of reestablishment of the forest has been successfully met. Additionally, valuable insights into the processes of ecological recovery have been and continue to be a result of past and current research in the Mount St. Helens volcanic area.

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Biological Legacies: A Critical Management Concept from Mount St. Helens

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Introduction

Studies of early successional recovery of communities following catastrophic disturbance generally give little attention to influences of the pre-disturbance ecosystem. For example, the role of migration or reinvasion of organisms is typically emphasized while surviving organisms are largely ignored.

Increasingly, disturbances are recognized as "editing" processes which, however, leave behind varying levels of organisms, structures and patterns. These biotically derived legacies from the predisturbance ecosystem can have important influences on the paths and rates of succession. Further, since there is a continuum of disturbance intensities, similar gradients exist in these legacies.

As defined here, biological legacies refer to: living organisms that survive a catastrophe; organic debris, particularly the large organically-derived structures; and biotically derived patterns in soils and understories. The living legacies may take a variety of forms, including intact plants and animals, perenating structures (e.g., rhizomes) and dormant spores and seeds. Important biotically-derived structures include dead trees (snags) and down logs, large soil aggregates and dense mats of fungal hyphae. These structures are increasingly appreciated for their role in ecosystem functioning, such as the importance of large woody structures as animal habitat (Harmon et al. 1986, Maser et al. 1988). Pattern legacies include those created in soil properties—chemical, physical, and microbiological—through the action of plants and their litter, and patterns in understory vegetation associated with variations in canopy light conditions.

In this paper, I outline the role that the 1980 eruption of Mount St. Helens played in the rediscovery of the importance of biological legacies in ecosystem recovery. The research conducted there provided clear evidence of the importance of both living and dead organic legacies following natural catastrophe. It stimulated a re-examination of the recovery processes following other natural catastrophes, including wildfire and windstorm, and a comparison with recovery following human disturbances, particularly clearcutting. The recognized importance of biological legacies in ensuring rapid redevelopment of compositionally and structurally diverse ecosystems is being strongly reflected in the development of management systems for natural resources with improved abilities to maintain ecological values.

Recovery in the Mount St. Helens Ecosystem

The eruption of Mount St. Helens on May 18, 1980 devastated more than 125,000 acres (50,000 ha) of mountainous forest lands and associated streams and lakes in the southern Washington Cascade Range (Franklin et al. 1985, 1988). Ashfall covered a much larger area. The 1980 eruption was, in fact, a complex series of events with multiple and varied impacts. Major volcanic habitats created within the blast zone by the eruption included debris avalanche, pyroclastic flows, lahars or mudflows, blast-downed forest and scorched forests. Environmental conditions, such as nutrients and moisture, and levels of biological legacies varied widely across this spectrum of habitats.

Mechanisms by which living organisms survived were highly varied (Franklin et al. 1985). Vascular plants most commonly survived by having reproductive structures, such as buds, in protected locations beneath the ground surface. Vertebrate and invertebrate animals also survived the eruption below ground. Deposits of ash were typically sufficiently thin and friable that many plant shoots could penetrate them and animals could free themselves from their burial. Conditions for surviving animals varied from moderately favorable to poor depending upon food availability, susceptibility to abrasive effects of the ash and tolerance of environmental extremes.

Ten years later levels of recovery are highly variable throughout the devastated zone (Franklin et al. 1988). The most important variable in recovery has been the level of biological legacies. Most of the other important variables—type of volcanic disturbance, type of pre-eruption ecosystem, snow conditions at the time of eruption, and post-disturbance erosion—have affected recovery primarily through their influence on numbers and kinds of surviving organisms and levels of organic debris.

The type and intensity of volcanic disturbance(s) at a given location were important variables that affected survivors and subsequent recovery processes. Most of the devastated zone was subjected to the blast and to ash fall. Such sites had survivor levels that largely reflected the pre-eruption community. For example, the legacy of large organic debris was very abundant on sites of blast-downed forest and included large numbers and volumes of logs and, in some cases, snags. Significant numbers of herbs, shrubs and fossorial animals also survived on these habitats. Areas subjected to pyroclastic flows, which were deposited at temperatures of up to 850°C, had almost no biological legacy of either living or dead material. The occurrence of live surviving plants on the debris avalanche was limited to transported plants or parts of plants (e.g., a piece of rootstock) that came to rest on the surface of the flow: the debris avalanche deposits were far too deep to allow buried organisms to emerge. The biological legacy on lahars was highly variable with locale, but did include viable plants and organic debris carried along with the lahar and plants that survived inundation or coating by the flow.

The type of pre-eruption ecosystem has had a significant influence on path and rate of recovery over much of the devastated zone. Areas clearcut prior to the eruption generally recovered more rapidly than adjacent areas of forests blown down by the blast. This is because clearcuts were generally dominated by communities composed of species such as fireweed (*Epilobium angustifolium*), thistle (*Cirsium* spp.) and pearly everlasting (*Anaphilis margaritaceae*). These were essentially preadapted weedy communities that vigorously sprouted after their aerial parts were destroyed. Herb and shrub species in the old-growth forests were generally not as well adapted to disturbances and the penetration of ash layers; surviving plants of these species were most often found on steep surfaces of root wads of windthrows.

Presence of snow was another important contributor to distinctive and rapid patterns of vegetative recovery. A patchy spring snowpack was still present at middle elevations and was continuous at high elevations at the time of the eruption. Plants or parts of plants enclosed within the snowpack were protected from the effects of the blast. Furthermore, the ash layers were disrupted and wetted by the melting snowpack; this facilitated penetration by fragile species. As a consequence, many high-elevation meadow communities appeared to have survived the eruption almost completely intact. Another important effect of the snowpack was survival of seedlings and saplings of coniferous tree species, such as mountain and western hemlocks (*Tsuga mertensiana* and *Heterophylla*) and Pacific silver fir (*Abies amabilis*). Because the native conifers are incapable of sprouting, conifers would have been eliminated throughout the devastated zone without the protection of snowpacks.

Erosion of ash and other sediment is the most important posteruption variable affecting recovery and, again, it has operated primarily through its influence on levels of biological legacies, particularly on the number of surviving plants. Generally, erosion of the ash mantle to the surface of the old soil has favored greater numbers and growth rates of surviving plants. Erosion freed plants from the mechanical impediment of burial. Deposition of additional sediment by landsliding, fluvial and volcanic processes has, on the other hand, strongly retarded vegetative recovery.

Management Application of Biological Legacies

One of the surprising lessons from Mount St. Helens was the importance of biological legacies—surviving organisms and organic debris—in the process of ecosystem recovery. The abundance of plant and animal survivors and their early importance were unexpected given the lunar appearance of the landscape immediately following the eruption.

This experience stimulated ecosystem scientists in the Pacific Northwest to look again at the processes of ecosystem recovery after other catastrophic disturbances, including clearcut logging. It was immediately apparent that, while most natural catastrophes, such as wildfire and windstorm, typically convert many trees from living to snags and down logs, very little organic material is actually removed (*see*, e.g., Spies et al. 1988, Maser et al. 1988). Furthermore, many of the plant and animal species found in the forest survive; this often includes mature specimens of the tree species. The result is that recovering ecosystems receive very large legacies of both living organisms and organic structures; compositional and structural diversity is, therefore, often high even in young natural forests.

Biological legacies are typically much lower following clearcut logging of forests. While many of the original plant species may survive, the level of living legacies is strongly and negatively influenced by the intensity of the management practices (*see*, e.g., Halpern 1988, 1989). Legacies of large organic structures, such as snags and down logs, are very drastically reduced under most current silvicultural practices, which include both harvest and slash disposal operations. The result is that the young forests that develop following traditional clearcut practices are typically much simpler in composition and structure than those which develop following natural disturbances.

The lesson of biological legacies is proving to have major relevance to development of forest management systems which attempt to better integrate ecological values, including wildlife, and commodity production (Franklin et al. 1986, 1989). These approaches are sometimes referred to as "New Forestry." Structural diversity is particularly important to a variety of forest functions, including provision of wildlife habitat. Therefore, silvicultural systems are being designed that provide for higher levels of structural diversity at all stages in managed forest stands. Some specific practices include provision for a continuous supply of large snags and down logs, development of compositionally and structurally diverse managed stands and maintanence of large green trees on cutover areas by substituting partial cutting practices for clearcutting.

Biological legacies is a concept with broad relevance to the management of ecosystems for higher levels of genetic and structural diversity. It is obviously applicable to commodity forests and rangelands where harvest or other management techniques may reduce diversity. It is also a useful concept in considering management objectives and techniques in natural landscapes, such as National Parks and Wilderness.

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Hurricane Hugo's Initial Effects on Red-cockaded Woodpeckers in the Francis Marion National Forest

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The Francis Marion National Forest (FMNF) in coastal South Carolina had the premier population of red-cockaded woodpeckers (*Picoides borealis*), a federally-listed endangered species. The population was the densest, the second largest and the only one known to have been increasing (Costa and Escano 1989). On the evening of 21 September 1989, Hurricane Hugo scored a direct hit on the FMNF. Immediate damage to the forest in the form of broken and wind-thrown trees was severe. Most of the cavity trees essential for woodpecker nesting and roosting, as well as much of its foraging habitat were destroyed. Many of the woodpeckers were probably killed.

This paper documents the initial impact of Hugo on red-cockaded woodpeckers in the FMNF, describes the immediate restoration effort and puts Hugo in historical perspective. Given that hurricanes are not rare events, we discuss possible strategies for lessening their impacts on this endangered species.

Impact on the Red-cockaded Woodpecker

Red-cockaded woodpeckers depend on the cavities they excavate in living pines for nesting and roosting. Excavation typically requires several years. Completed cavities are generally used for several years and sometimes for as long as 20 years. Cavity trees are critical to the woodpecker, and the lack of potential trees for cavity excavation is a primary reason the species is endangered (USFWS 1985).

After Hugo, Forest Service biologists attempted to visit all known colony sites (clusters of cavity trees) to assess damage and prescribe emergency management. The damage estimates that follow are based on these visits. Ninety-nine percent of all known colony sites were visited and 91 percent were censused for surviving woodpeckers.

Hugo destroyed 87 percent of the estimated 1765 cavities that were active prior to Hugo (ones with evidence of recent use by the bird). At 47 percent of colony sites that were occupied by red-cockaded woodpeckers before the storm, all the trees with active, inactive and incomplete cavities were destroyed. At 57 percent of colony sites with woodpeckers prior to Hugo, all trees with active cavities were destroyed.

In the 205 colony sites that had at least one active cavity remaining after the hurricane, the average number of active cavities was only 1.9. In 1988, the number of active cavities per colony averaged 3.7 in 100 randomly selected colony sites. Thus, the quality of surviving colony sites was less than prior to Hugo.

Only 10 dead red-cockaded woodpeckers were found. However, based on the mean number of surviving birds per colony (1.5) and the mean number of birds per colony determined in prior years for October (4.0), we estimate that 63 percent of the woodpeckers in FMNF were killed or missing. Seventy-seven percent of all colony sites, 89 percent of sites with surviving cavity trees, and 52 percent of those with no surviving cavity trees still had woodpeckers after the hurricane.

In 1987–88 there was an estimated 477 family groups of from 2–9 red-cockaded woodpeckers (= clan) in the FMNF. After the hurricane there were 240 colony sites with some surviving cavity trees (active, inactive or incomplete cavity) that still had 1 or more woodpeckers. Another 128 former colony sites without any surviving cavity trees still had 1 or more birds. Thus, the most optimistic estimate for the post-Hugo population is 368 clans. However, only 67 percent of these had the 2 or more birds necessary for a potentially functional clan. Even under the best of conditions it is unlikely that all of these will survive for more than 1 year following the hurricane. We expect a continued loss of clans before the population stabilizes. When this occurs and where the population will be at the time depends on survival of birds over-winter without cavities, the success of single birds in finding mates, survival of the remaining cavity trees, survival of foraging habitat in the face of wildfire and beetle attacks, the juxtaposition of remaining foraging habitat to colony sites, reproductive success in the next few years, the rate of new cavity excavation, interspecific competition for cavities, and the success of restoration efforts.

Impact on the Forest

The destruction of pines that were not cavity trees were also severe. Quantitative data are not yet available, but it is thought that at least 50–60 percent of the pine sawtimber trees on the FMNF were destroyed. These trees served as foraging habitat and replacement cavity trees. Not all pine stands were affected equally by winds of the same force. Damage to the forest appeared to be a function of both tree age and number of trees per acre. Sapling and young pole stands were frequently heavily damaged, but many of these may still be manageable without regeneration. Many stands in the 30–40 year age class escaped with moderate damage. Mature pine stands (more than 80 years old) with low to moderate basal areas (about 70 square feet per acre or less [16.1 m^2/ha]) typically had less than 10 square feet per acre (2.3 m^2/ha) in standing trees after the hurricane. Unfortunately, such stands are the most valuable to the red-cockaded woodpecker as both existing and potential new colony sites. Mature pine stands with high basal areas (more than 90 square feet per acre [20.7 m^2/ha]) escaped some of the strongest winds with moderate damage.

Hugo set the stage for a continuing process of destruction to the forest. Pines that survived the hurricane are subject to attack from engraver beetles (*Ips* spp.) and turpentine beetles (*Dendroctonus terebrans*). Additional trees will die from these attacks. Many of the pines that appear to have survived suffered root, bole and crown damage that will contribute to additional mortality. Also, with the enormous fuel loads the chance of a catastrophic wildfire is great. Only time will determine the final loss to the forest from Hurricane Hugo.

Hugo in Perspective

Hugo is called a ''Cape Verde hurricane'' because of its origin near Africa (Lawrence 1989). Only a small percentage of such hurricanes make landfall in the United States, but of the 13 that have since 1906, 9 were major hurricanes (category III–IV) (USACE 1986).

Hugo was a powerful category IV hurricane with maximum sustained winds estimated at 135 mph (217 km/hr) at Bulls Bay 20 miles (32 km) north of Charleston, S.C. (Lawrence 1989). Near the coast, hurricane force winds (more than 74 mph [119 km/hr]) appeared to have occurred in a band at least 55 miles (86 km) wide. The eye was about 24 miles (39 km) wide (J.V. Purvis, pers. comm.). Sustained winds of hurricane force occurred at least 90 miles (145 km) inland and gusts of 80 mph (129 km/hr) were reported at Hickory, N.C., 220 miles (354 km) inland (Lawrence 1989).

Approximately 14 other hurricanes approaching or exceeding Hugo's strength have made landfall within the range of the red-cockaded woodpecker (Texas to Virginia) since 1899 (NOAA 1977, USACE 1986). Thus, such a storm occurs in the birds range about every six years. Over 100 lesser hurricanes have made landfall during the same period (Neumann et al. 1987).

In South Carolina, the periodicity of hurricane landfall is about every six years (about 34 between 1786–1985) (Langley and Marter 1973, USACE 1986). A probable category IV hurricane landed in South Carolina in 1893 and another in 1954 (USACE 1986). Including Hugo, South Carolina has had three category IV hurricanes in the past 96 years. Experts consider Hugo to be a 1 in 100 year event in South Carolina (J.C. Purvis pers. comm.).

Since 1700, there appear to have been about 18 hurricanes that probably affected the FMNF (Langley and Marter 1973, Calhoun 1983, USACE 1986, Neumann et al. 1987). These data suggest the FMNF is subjected to hurricane-force winds about every 16 years. This estimate may be inflated because it is impossible to get specific information about the early hurricanes. However, the mean elapsed time between hurricanes is fairly stable across centuries (1700s = 16.7, 1800s = 14.3, and the 1900s = 17.8). Clearly, not all these hurricanes had the same effect as Hugo, but cavity trees are at risk relatively frequently.

Restoration Efforts

Cavity excavation typically takes more than one year, and most clans without cavities probably would not survive. Artificial cavities are being constructed in colony sites where there are less than two natural cavities in good condition and at least a minimal amount of foraging habitat remains. Several experimental techniques are being used. The first involves drilling two intersecting holes and then plugging one to create a cavity. An abbreviation of this procedure involving one drilled hole to form a partially completed cavity is also being used. These two techniques were developed by Carole Copeyon, a graduate student at North Carolina State University. A third technique, developed by David Allen, a Forest Service biologist, involves inserting a preconstructed cavity into a rectangular hole cut into a pine tree with a modified chainsaw.

At this writing (15 March), 470 artificial cavities have been installed in 154 colony sites in most immediate need of cavities. These sites require additional artificial cavities as do nearly 100 other sites with inadequate or unsuitable cavity trees surviving.

At least 40 percent of the artificial cavities are in use. In time we think nearly all will be used. Copeyon (pers. comm.) has had red-cockaded woodpeckers nest successfully in the drill cavities. Thus far, birds have not had an opportunity to nest in the preconstructed cavities (Allen pers. comm.). Hopefully, the man-made cavities will sustain the population long enough for the birds to excavate their own cavities.

Effort is being made to salvage as much of the approximately 1 billion board feet of destroyed timber as possible. Salvage benefits the red-cockaded woodpecker by reducing both fire and beetle hazard, and offers a better chance to control adverse midstory conditions that would be severely detrimental to the red-cockaded woodpecker. Unfortunately, less than 25 percent of the salvageable timber will probably be removed before it deteriorates. To benefit the woodpecker, all standing live pines, unless leaning more than 45 degrees (and thus most likely to have sustained fatal root damage) are being retained during the salvage.

Fire suppression efforts are intense. They are aimed at preventing fires through construction of about 100 miles (160 km) of fuel breaks and through public education, and at the rapid detection and suppression of fires. Thus far since the hurricane, 49 wildfires have been suppressed before they could develop into a major fire.

Discussion

The red-cockaded woodpecker and the coastal plain forest evolved with hurricanes. A review of hurricane periodicity shows that hurricanes are not rare events in the southern coastal plain. Even major hurricanes such as Hugo should not be considered rare in the context of providing habitat for a viable population of red-cockaded woodpeckers in perpetuity. The question is not if a hurricane will hit, but when. Given that truism, a more important question is how then to protect the red-cockaded woodpecker in the face of continuing disasters.

The best biological answer is appealing but impractical: revert back to pre-Columbian conditions. In that era, hurricanes no doubt destroyed large areas of red-cockaded woodpecker habitat and killed large numbers of the birds, but had relatively little impact on the species as a whole. Now, with the bird existing in habitat islands, hurricanes are a menance to the species.

The next best answer is to have as many geographically large populations as possible. An extensive population is desirable because a single hurricane is less likely to destroy the entire population beyond the point that it can recover. Cooperative management agreements with owners of private land adjacent to public land with red-cockaded woodpeckers may be the most practical way to increase the geographic extent of a population.

More study is needed, but we are intrigued by the apparent direct relationship between stand density (trees per acre) and tree survival. Others have observed a similar relationship following hurricanes (Trousdell 1955, Trousdell et al. 1965). It might be possible to "hurricane proof" a forest by having more densely stocked stands of pine than is currently practiced. Survival of pine stands appears to be age related also. Thus a balance of age classes and a spatially uniform distribution of stands within age classes seems beneficial. Cavity trees appear to be two to four times more vulnerable than trees without cavities and we doubt that many could survive hurricane force winds. However, the more foraging habitat and potential cavity trees that survive a hurricane, the more probable the recovery of a population.

The damaging effects of hurricanes are well delineated geographically and damage lessens as one moves out from the area of most intense winds. For example, with Hugo, cavity trees were destroyed in a band 52 miles (84 km) wide, but loss of cavity trees varied from more than 90 percent to less than 40 percent within this band. Thus, having colony sites uniformly dispersed within the geographic limit of a population (as opposed to having most of the colony sites clumped in one area) would lessen the chance of losing an entire population.

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Closing Remarks

Carlton Jackson
American Petroleum Institute
Washington, D.C.

Our panelists today have talked about events which have had a significant impact on the environment. They have raised questions for policymakers to consider and, more importantly, for the public to think about. What have we learned? I, for one, heard one thing I didn't know. There was no fire in the original story of Bambi—the fire was added by Hollywood.

But forest fires, shipping accidents, volcano eruptions, hurricanes and other unpredictable events do have an impact on the environment. Endangered species, no matter how man seeks to improve their habitats and protect them, face natural dangers from which they cannot be protected. The effects of Hurricane Hugo on the woodpeckers of South Carolina are an excellent illustration of that fact.

That does not mean we are powerless. All of our speakers have made one thing abundantly clear—we must be willing to adapt and to learn from what has happened in the past, especially when mistakes were made.

As Steve Mealey mentioned earlier, the earth is growing smaller and we have to work together to forge new partnerships. The recent political changes in Eastern Europe drive this point home. But, while the world is smaller in some ways, it is also larger. The population is growing. Third World and Eastern European nations are developing their economies. More people are demanding more resources, and the industrial growth that accompanies those demands inevitably impacts our environment.

Are we facing a crisis? I don't think so. However, we must ask what we can do to protect wildlife and its habitats. I have no ready-made answers. I leave the solutions to each of you, the professionals. I do believe that continued research can lead to decisions which allow man and wildlife to better share our environment.

Within hours after Hurricane Hugo devastated South Carolina, food, clothing, money and provision for new shelter were rushed in to help the area's residents meet their environmental needs. So far as I know, little or nothing has been done to address the environmental needs of other species that were affected by the disaster. Should something be done? This is a question that deserves more than passing thought.

Society is demanding more from business, industry and government. People want low cost goods and services. They also want the environment protected from risks or damage. The challenge for all of us is to balance that seesaw.

If we are to achieve that balance, we need to communicate. We must develop better relationships with all the different groups and individuals involved in this critical issue—industry, government, conservationists and the media. We must talk with those who share our concerns and our interests and strengthen our ties with them. We also must reach out to those with whom we disagree and those who aren't even part of the dialogue. We need to work together to solve the problems we face, both domestically and internationally. A free exchange of ideas can lead to methods of protecting the environment that do not damage our economic health in the process. It should not be us versus them.

As a result of the spill in Alaska, the petroleum industry is planning to spend nearly half a billion dollars to set up a series of oil spill response centers capable of handling Valdez-sized spills. State and federal lawmakers have proposed, and are implementing, new laws and regulations to protect against such spills.

The fires in Yellowstone have reopened the debate of firefighting policy and land management.

Nearly a decade after the devastating eruption of Mount St. Helens, the ecosystem is recovering. The research and management techniques learned from this experience—and the others I just mentioned—should help us prepare for "unpredicted events" in the future.

I have no doubts that at future meetings like this you will attend similar programs. No matter how many plans are in place, there will always be "unpredictable events." Such events are always tragedies. It would be a greater tragedy, however, if we failed to learn from them.

If we are to learn, we must listen. Then, we must revise our response strategies as new information and new techniques become available. Finally, when the unexpected occurs, we must be prepared to act. Taken together, these three steps can lead us to greater success in the future.

Special Session 5. *Conservation Law Enforcement*

Chair
JAMES A. TIMMERMAN, JR.
South Carolina Wildlife and Marine Resources Department
Columbia

Cochair
ROBERT B. KING
Missouri Department of Conservation
Jefferson City

Opening Remarks

James A. Timmerman, Jr.
South Carolina Wildlife and Marine Resources Department
Columbia

In reviewing law enforcement forums such as this, even as far back as the 1940s, there are several issues that seem to stand out as recurring themes. Those are the topics of professionalism and public relations as they relate to resources law enforcement.

Where our biologists may be primarily concerned with wildlife's relationship with the environment, law enforcement is concerned primarily with people and people's relationship with the environment.

There is no question that well-trained, well-equipped and motivated resource enforcement officers can have a great positive impact. They impact both the agency's management effort and the public's perception of that agency.

Our topics here today demonstrate the changing dynamics of the management of resource utilization. They demonstrate the clear need to maintain a professionally prepared and equipped law enforcement program in step with those changes.

It is no longer adequate to provide a resource officer with basic law enforcement training and give him a good looking uniform, a vehicle, a ticket book and send him into the woods.

We have evolved light years away from those simpler times. National, as well as world population increases, have imposed dangerously significant pressures on natural resources. In a time of interrelated impacts, no one issue stands alone.

As these pressures have increased so has the demand for redefining the standards and goals of law enforcement.

An effective officer now must be knowledgeable about more than just what he may run into in his own county or state. He must be familiar with a body of national and international conventions. Far-reaching laws may regulate a wildlife resource with habitat a continent or an ocean away.

As world technology has developed, so too has the sophistication of the poacher. He may no longer merely be just a knowledgeable woodsman, but may have all the modern advances in transportation, communication and weaponry. The modern poacher may not be trafficking in illegal resources taken only in his own state. He may have an elaborate interstate or even international marketplace.

Beyond the poaching problems that traditionally have been associated with the mainstream of wildlife enforcement activity, there are emerging problems that adversely affect wildlife and wildlife habitat.

They involve environmental degradation such as air and water pollution, encroachment on woodlands and wetlands by development, organized anti-hunting sentiment, conflicting recreational demands on wildlife management areas and other problems that, in the past, were not a part of wildlife law enforcement functions.

Crucial to combating problems of that magnitude will be cooperation—and lots of it—cooperation between law enforcement and other levels of management; interagency cooperation, cooperation between states, between states and federal government and with concerned citizens and conservation groups.

Those who fail to take the initiative and sit and wait for things to happen are going to get an education the hard way, as natural resources and scarce habitat in their areas are preempted by adverse interests capitalizing on the unwary or unprepared.

Keeping laws up-to-date with the priorities of resource management is vital. Constructing them to be reasonable and understandable is equally important. But all of the best conceived management plans and their enabling legislation will be hollow exercises without a professionally prepared law enforcement program equipped to deal with contemporary resource problems head on.

The future of law enforcement lies in the continuation of long-standing efforts to develop and maintain effective relations with the public we serve. We must encourage voluntary compliance with protective laws and their willing support of various management programs.

The bedrock of any successful resource public relations effort is a well-informed, well-trained and well-equipped resource enforcement officer who is prepared to deal with a variety of contemporary national resource issues, each of which can—and likely will—develop into a platform for a public hearing.

We will hear papers today that expand on some of these themes and indicate the challenges and the directions of wildlife law enforcement in the decade of the 1990s.

The 1990 Guy Bradley Award

Charles H. Collins
Executive Director
National Fish and Wildlife Foundation
Washington, D.C.

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

Picked from a field of outstanding nominees, the 1990 recipients more than meet these qualifications. They were selected by a volunteer panel of judges comprised of seven representatives from federal and state wildlife agencies and conservation organizations. The Foundation is honored to present the 1990 Guy Bradley Award to Rex Corsi of the Wyoming Game and Fish Department and Benjamin Moise of the South Carolina Wildlife and Marine Resources Department.

Rex Corsi—Wyoming Game and Fish

Rex's career spanned four decades from 1951 until his retirement in 1989. During Rex's tenure as game warden in Wyoming, he set the standard for hard work and dedication to his job, his department and the wildlife resource. Rex was often the only law in town and brought many game violators to justice. He excelled in every aspect of law enforcement and was considered one of the best marksmen in the Wyoming Game and Fish Department. Respect earned from his peers and superiors led to his promotion to the highest law enforcement position with the Department.

During Rex's tenure as Chief Game Warden, equipment, personnel, training, record keeping and innovative approaches to increasing enforcement efficiency insured that the Wyoming Game and Fish Department's enforcement effort excelled. Also during this period, Rex was instrumental in obtaining full peace officer status for game and fish officers. Rex represented the department on a variety of boards and committees, and served actively on committees in the Western Association of Game and Fish Agencies. He regularly lectured at the Wyoming Law Enforcement Academy and sat on the selection board for hiring instructors at the Academy. In summary, Rex Corsi was a leader in wildlife law enforcement in the Wyoming Game and Fish Department for almost 40 years. Officers of the Department continue to excel in their profession—thanks in large part to the leadership of Rex Corsi, retired Chief Game Warden.

Ben Moise—South Carolina Wildlife and Marine Resources

Ben Moise has been a Conservation Officer with the South Carolina Wildlife and Marine Resources Department since 1978, after serving four years in the Coast Guard and enjoying brief careers as a school psychologist and as a newspaper writer. Ben earned a B.A. degree in psychology from the University of South Carolina and a Masters Degree in Human Relations from Webster University.

Ben has made significant contributions to the department's law enforcement effort. He served for six years as a member of the undercover operations team, where, with patience and ingenuity, he was instrumental in breaking up illegal commercial operations in a number of small communities along the South Carolina coast. Representative of his interest in wildlife education, Ben has written many articles for magazines and newspapers; he has produced, of his own initiative and expense, two 30-minute slide programs, one on marine law enforcement and the other on the enforcement of the Migratory Bird Treaty Act.

Ben's superiors also name his actions during Hurricane Hugo. He assisted Charleston City Police and the Emergency Preparedness Center, before, during, and after the storm's direct hit on Charleston. It is symbolic of his dedication that he did not stop to attend to substantial personal losses until the initial public crisis was under control. Lieutenant Ben Moise currently serves as the Law Enforcement Division's Marine Liaison Officer. He is a Life Sponsor with Ducks Unlimited, a board member of the Lowcountry Open Land Trust and is active in many other conservation organizations on both a national and state level.

The Award

In recognition of Rex and Ben's efforts on behalf of national wildlife conservation, the National Fish and Wildlife Foundation is pleased to present them each with the Foundation's 1989 conservation print with a commemorative plaque and a check for $1,000.

In closing, I would like to restate the obvious. Wildlife violations occur 365 days a year, 24 hours a day. The poacher doesn't keep a 9–5 schedule, but more likely will work at night or on the holidays. The bad weather that grounds geese and helicopters is likely to bring the outlaw gunner out. These are the hours and weather conditions under which the law enforcement officer works. Chronically understaffed and vastly outnumbered, the law enforcement agent, state or federal, represents a "thin green line" to conserving this nation's fish, wildlife and plant resources for future generations.

The Foundation applauds Rex Corsi, Benjamin Moise and the hundreds of other dedicated wildlife law enforcement officers who also deserve this recognition. The Foundation would like to thank Clark Bavin, Terry Crawforth, Ken Goddard, Terry Grosz, Larry Jahn, Ron Marcoux, and Max Peterson for their willingness to serve as the Guy Bradley Award judges. Finally, our thanks to the Wildlife Management Institute for its help in this presentation.

Natural Resource Law Enforcement in the 1990s: Meeting the Challenge

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Introduction

Natural resource law enforcement, as with all facets of resource management, has evolved from its rather inauspicious beginning with limited public support to a major component of society's effort to protect its own well-being. Never has society's support for resource protection and enforcement been higher and, by all indications, it will continue to increase. As evolution brings advances in resource enforcement, new challenges will arise and additional adjustment will be required to meet them.

It is not my intent to predict the future with certainty, but to review the past, take stock of the present and gain at least some perspective of what the future holds. Coupling this insight with one's view of what the future should be provides an indication of what lies ahead and an opportunity to plan for this future. This paper seeks to define the major challenges facing natural resource law enforcement in 1990s to perhaps help agencies better plan how to respond.

These comments will not apply equally to all states, as some are already involved in varying degrees with the enforcement activities I will discuss. However, I believe those that are not so involved will or should be, and those that are will become more so.

Past

I will not dwell on the past, as the history and evolution of natural resource enforcement is generally known to those interested in resource protection. Suffice it to say, enforcement has come a long way from the days when its traditional, and perhaps only responsibilities, were to check licenses and catch those who were illegally taking fish or wildlife; when wildlife violations were viewed by the public as inconsequential, and not really considered law violations, and were treated by the courts with indifference, if at all; when officers were hired more for their political connection than job qualifications; and when "game wardens" were not considered "real" law enforcement officers, either by the public or by other enforcement agencies. Unfortunately, though we have come a long way, we still live with some of this residue of the past and must still strive to overcome it.

Present

Today's natural resource enforcement officer is considerably better qualified, trained, equipped and more empowered than his predecessor. He or she must compete with a large number of applicants for relatively few positions, and political connections usually have little or no significance. He must satisfactorily complete increasingly complex initial training and continuous in-service training, which in many states includes the addition of mandatory courses and skills necessary to meet minimum police standards required of all enforcement officers. He must be knowledgeable of and able to explain a myriad of laws that would be complex even to the proverbial Philadelphia lawyer. He must be capable of dealing with a wide array of enforcement situations totally unrelated to his traditional enforcement duties.

Most all state resource enforcement officers now have enforcement authority considerably beyond their traditional fish and wildlife agency powers. Many enjoy full state police officer status, empowered to make arrests for most, if not all, criminal violations they may encounter. Salary and benefits are more competitive, if not yet equitable, with other comparable enforcement entities.

They also enjoy much greater respect and support than ever before. As the public has become more aware of environmental degradation and its attendant adverse impacts on fish and wildlife resources, they not only support but demand greater protective measures, including enforcement. This is evident by the fines and penalties for wildlife violations being imposed today against individuals and corporations—penalties that would have been unthinkable just a few years ago.

The expansion of enforcement duties into the areas of boating, litter and waste disposal, pollution control, captive wildlife, trespass and general public protection have brought us into contact with a different and larger segment of the public than in the past. This has generally resulted in a larger supporting constituency.

Resource enforcement officers are increasingly recognized by the law enforcement community as enforcement professionals and valuable allies, and are being accepted as equals. They have demonstrated that they can provide significant and important support to other enforcement agencies when called upon or when confronted with enforcement situations beyond their traditional role. In turn, other enforcement entities often become allies in their resource protection efforts.

The expanded authority and role of the resource enforcement officer, particularly the acquisition and use of full police powers, does bring additional problems. Some resource management professionals have expressed concerns about such expansion, ranging from mild to vehement opposition, and there is justification for concern. Some agency enforcement emphasis may be diverted from resource protection. There is a danger some resource officers may devote too much time to non-resource enforcement activities or excessive requests for assistance may be made by other agencies at the expense of resource protection. There is the possibility of strengthening the position of proponents of a state police force that would absorb the enforcement arm of the resource agency. There is the chance that at least a portion of traditional agency funding would be used to pay for non-resource enforcement.

Despite these legitimate concerns, expansion of enforcement activity and authority beyond the traditional role is essential to continued increase in public and political support, to successful competition with other entities and interests for personnel and funding; and ultimately, to improved resource agency ability to protect natural resources.

The concerns that have been listed, as well as many others, can be addressed satisfactorily. Resource protection must remain the foremost objective and interest of the enforcement branch and its officers, and no erosion of this emphasis can be allowed. Expanded authority must be cautiously and prudently utilized and controlled by strict adherence to specific agency guidelines. Excessive or improper exercise of authority cannot be tolerated and must be appropriately dealt with to prevent misuse. Sources other than traditional resource funding must be sought and provided to pay for non-resource enforcement activities. This will likely mean seeking general fund appropriations, which is also opposed by some resource administrators who believe such funding would result in loss of autonomy or undesirable political intrusion, or both. But, it is believed these dangers are more perceived than real. There is no question that expanding the role and authority of natural resources enforcement brings problems, but they are manageable and are far outweighed by the potential benefits to the resource agency and, thereby, to resource protection.

Future

The challenge of the nineties, for the most part, will be to increase involvement in the additional enforcement programs already initiated in the eighties and other identified as appropriate in the nineties, without loss of effectiveness in the more traditional resource protection efforts. The enforcement of laws and regulations governing the taking of wildlife to assure that no species becomes threatened or significantly depressed because of illegal taking must remain the basic objective of resource enforcement. Great success has been achieved in accomplishing this responsibility, and erosion of the gains that have been made must not be allowed.

The nineties will bring a shift in the nature of the more traditional resource protection efforts, generated to a large extent by a better informed and more concerned public. The average age of resource users will increase. This will contribute to lower violation rate per user, a greater questioning of enforcement methods and efforts, and a demand for "better service" in the delivery of enforcement efforts. A shift in public attitudes toward wildlife to more humanistic and moralistic views will also occur. This, coupled with increased urban/suburban encroachment into wildlife habitat, will lead to more nuisance wildlife complaints and increased public expectation that the animal be removed humanely or relocated instead of destroyed.

The laws regulating the taking of fish and wildlife have become increasingly complex. They will become even more so in attempts to balance biological considerations with optimum user opportunity, with increasing numbers and types of users, and with, more often than not, a decreasing land base. It is a difficult and complex task, but one which must be met. This means that the resource enforcement officer must be better trained and informed. He must keep abreast of additional laws and their frequent changes, and enforce these laws with reason and prudence. He must accept a greater responsibility in keeping the public informed as these changes occur.

Threatened, endangered and nongame wildlife. Enforcement's role in the protection of threatened, endangered and nongame wildlife, as well as protected plant life, will greatly increase due to public demands based on a broader interest in all resources. While this creates an additional enforcement burden, it is not only appropriate, but it also provides the opportunity to gain support from a vastly broader constituency than traditional hunters and fishermen.

In some states such as Florida, specialized enforcement programs have been developed to protect endangered species. For example, Florida wildlife officers regularly write traffic citations while patrolling "panther speed zones" on the Alligator Alley in the Everglades. Because the panther is particularly vulnerable to automobile strikes, night-time speed limits are set at 45 m.p.h. in the "zones." Since 1985, wildlife officers have made over 4,000 speeding arrests and written 500 warnings during late-night patrols of these areas. We believe this program has been effective in reducing panther fatalities. Similar speed reduction programs are in place for the Key deer, and boating speed zones have been established to protect the manatee.

Boating. Boating regulation and enforcement is already primarily the responsibility of the natural resource agency in many states, and most others have at least some degree of involvement. This is entirely appropriate for these agencies to have an existing force of professional officers already in the field contacting boaters while performing resource protection duties. This is not to imply that incidental boating enforcement can constitute the entire boating enforcement program, but it can constitute a major portion. As in resource management, additional and more complex laws are forthcoming to regulate boating. States already have at least some laws governing boat registration and operation, addressing such areas as operating under the influence of alcohol or drugs, reckless operation, speed limits, motor restriction, safety equipment and boater liability. To properly enforce these laws, resource enforcement officers must be appropriately trained and proficient in areas beyond their traditional ones such as detection and substantiation of substance abuse, and accident investigation. Utilization of specialty equipment such as breath and blood analyzers and speed detection devices must be a part of their skills. Officers must learn and stay current on an entirely distinct set of laws from resource protection. Boating enforcement, while an additional responsibility, again offers an excellent opportunity to greatly broaden constituency support.

Environmental crimes. Environmental degradation has emerged as one of the greatest concerns of the American public in the eighties and this concern is predicted to intensify in the nineties. This concern translates into public demand for additional laws and more effective enforcement.

We have learned, and are learning more each day, that many of man's past activities and practices can no longer be tolerated. They not only degrade our quality of life but threaten our very existence. Health advisories warn against consuming fish from many of our waters and caution against frequent consumption from many others; heavy metals and pesticides are being found in numerous species of fish and wildlife, the full consequences of which are yet unknown; contamination of surface and subsurface waters is increasingly evident, creating problems for both wildlife and humans; and there is evidence that atmospheric contamination is adversely affecting plant life and weather patterns, as well as having a direct impact on human health. Fortunately, as we become more aware of these negative impacts, laws are being passed to minimize or prohibit them, though perhaps not as fast as we may like or as may be necessary.

Human activities ranging from simple littering to felony dumping, improper deleterious waste disposal, indiscriminate dredging and filling of wetlands and improper use of pesticides and other chemicals are no longer acceptable, and are generally prohibited by criminal laws. However, enforcement has not been adequate to ensure compliance. As landfills become less available or acceptable, as disposal of hazardous substances becomes more difficult, and as compliance with laws becomes more burdensome and costly, an attendant increase in violations can be anticipated. There will always be certain elements of society who do not comply with laws for various reasons. Some will violate from ignorance, some because it is easier and cheaper, and some, as with the criminal-minded, with the intent to engage in a monetarily profitable enterprise.

Because of the potentially devastating impact these activities have on natural resources, the extent of which we are yet to realize, natural resource agencies must have a major, if not the lead, role in environmental enforcement. This should be the case whether the laws are made by the natural resource agency or other governmental entity.

Again, the resource enforcement officer is most likely already on the scene and frequently comes into contact with such violations or the results of them while performing his traditional resource enforcement duties. Even more so than in boating, specialization in enforcement of environmental laws is required. However, the natural resource agency already has considerable expertise and assistance available from biologists, environmental specialists and, in some instances, chemists and laboratory capability.

Already, some states have begun to train specialized law enforcement personnel to pursue complex environmental violations on a full-time basis. This trend must continue because the illegal dumping of debris and hazardous chemicals is many times more devastating to our resources than a poacher's bullet or illegal net. The future of hunting and fish in America rests, at least partially, on the resource agencies' ability to prevent immediate and long-term damage to our fish and wildlife habitat.

Sophisticated training is mandatory for the resource enforcement officer to effectively assume these duties. He must also be properly equipped and provided with the necessary support services.

While the primary objective of the resource enforcement officer in enforcement of these laws is resource protection, the costs, and they will be considerable, should not be paid exclusively from traditional agency funding. For the most part, they should be borne by the general population, which will truly reap the greatest benefit from enforcement efforts.

Captive wildlife. Another activity that is requiring more involvement by resource enforcement officers is captive wildlife. Many states have extensive laws regulating possession of both native and exotic wildlife, and establish standards for humane treatment, care and secure confinement. Such laws usually apply whether possession is for personal or commercial purposes. Enforcement is already the responsibility of the resource agency in many states and is requiring an increasing share of their enforcement effort. Special expertise is also required to properly enforce these laws as they deal with conditions and species not usually encountered in traditional resource enforcement.

A resource agency's ability to deal with the regulation of captive wildlife, both native and exotic, is becoming of critical concern in many areas of the United States. The wildlife trade continues to grow at a rapid rate worldwide. Native species are being exploited for commercial and private use. Exotic species continue to be very popular as pets, zoological specimens and as objects of "game ranches" for entrepreneurs. In many areas, exotic species have become established, and likewise threaten our already fragile and overtaxed environments. Human safety is also a factor because of the popularity of pets such as lions, cougars and wolves.

General crimes. In addition to expansion into areas previously mentioned, resource enforcement officers will be increasingly involved in other criminal enforcement activities, either through contact while performing their normal duties or by being called upon for assistance by other agencies. During routine patrol today, officers frequently encounter drunken drivers, stolen vehicles, illegal drugs, fugitives from justice, civil disturbances and activities constituting eminent threats to persons or property. These situations cannot be ignored if officers are to be respected and supported by the public to the fullest extent and granted equality with other enforcement officers. They must be trained and ready to respond with appropriate action when confronted with such situations as, frequently, they are the only enforcement officers on the scene or readily available to do so.

Administration. Last but not least is the administrative challenge to do more with less. Enforcement workloads will increase faster than agency personnel and financial resources. The allocation of enforcement effort among the additional activities that have been discussed will become more difficult and complex. Agency enforcement will need to become more efficient and effective as a result. Improved management systems for planning enforcement activities and the implementation and evaluation of these activities will be critical to increasing efficiency and effectiveness. These management systems will become increasingly imperative as tools of top administrators in directing, coordinating and controlling enforcement activities.

Conclusions

While the duties and responsibilities of resource enforcement officers have been and will continue to be expanded, their primary role must remain traditional resource protection.

Expansion of resource enforcement beyond its traditional role should be directed at addressing a specific, identifiable enforcement need and carefully timed with public and political support. Attempting expansion without such support can have negative impacts not only on enforcement but other agency programs as well. Care must be taken to avoid the perception that expansion is intruding or usurping the responsibilities of other agencies, but rather is viewed as assistance and cooperation with them.

No single officer can be expected to be expert in all facets of the enforcement areas discussed, but they can acquire a working knowledge and the capability to properly respond to situations encountered. To achieve an acceptable degree of enforcement effectiveness, some areas will require specialized personnel working in discreet units dedicated primarily to specific enforcement programs.

Natural resource enforcement, as with all endeavors, is becoming increasingly expensive, and additional funding must be obtained to maintain effectiveness in fulfilling traditional responsibilities and, certainly, to expand into other areas. User fees, special taxes and general fund appropriations are all appropriate sources to fund the various parts of the enforcement effort and other sources should be sought.

It should be obvious that extensive, additional training is required. Agencies must be willing and able to commit significantly more resources than previously to training, for without adequate training, enforcement cannot be effective, whether traditional or expanded.

Natural resource enforcement is only a part, albeit a vital part, of resource management and conservation. Biological and educational efforts are also vital parts and must receive appropriate consideration when allocating agency resources. Enforcement is a necessary function of a natural resource agency, not an entity unto itself, and its advancement must be commensurate with, not at the expense of, other agency functions.

The decade of the nineties will bring increased challenges to resource enforcement, but it also brings increased opportunities to broaden agency constituency and public support, to gain additional personnel and funding and to play a greater, more effective role in environmental and resource protection.

Developments in Federal Regulation of the Wildlife Trade

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Introduction

Federal regulation of the import, export, and sale of wildlife has developed primarily as an outgrowth of the interstate commerce and foreign treaty provisions of the constitution (Bean 1977). While Federal migratory bird regulation developed early in the twentieth century, it was during the climate of increased environmental activity during the 1970s and 1980s that a number of new laws and treaties were developed giving the Federal Government broad powers to regulate endangered species, marine mammals, and conditions of import into the United States. These included the Marine Mammal Protection Act of 1972 (16 U.S.C. 1631–1407); the Endangered Species Act of 1973 (16 U.S.C. 1531–1543); the Convention on International Trade in Endangered Species of Wild Fauna and Flora (TIAS 8249), more commonly referred to by its acronym, CITES, negotiated in 1973 and implemented by the Endangered Species Act; and the humane transport amendment to the Lacey Act (18 U.S.C. 42 et seq.) of 1981. A number of key decisions in implementation of these laws will be required over the next few years. This paper summarizes some key decisions affecting international and interstate regulation of the wildlife trade which the U.S. Fish and Wildlife Service (FWS) will be required to make during the 1990s.

African Elephants

The African elephant (*Loxodonta africana*) was added to CITES Appendix II in 1976, in recognition of the need to carefully regulate the ivory trade. CITES party nations subsequently adopted a series of increasingly stringent measures (CITES 1982, 1984) designed to reverse the adverse effects on African elephant populations of excessive taking and illegal trade, culminating in a system of ivory export quotas and permits which the FWS adopted into its threatened species regulations (FWS 1986).

However, two 1988 studies (Caughley 1988, Ivory Trade Review Group 1988) revealed that the CITES system was not tight enough to stop the mixing of legal and illegal ivory, with the new ivory entering commerce each year far exceeding the sustained yield. Over half of Africa's elephants had disappeared in less than a decade, and the extirpation of most populations was likely within the next 10 years. Even in southern African nations with stable or increasing populations, effective internal elephant management programs were unable to control the mixing of legal with illegal ivory once it left Africa. To combat this deteriorating situation, in November, 1988, the President signed into law the African Elephant Conservation Act (Pub. Law 100–478, 16 U.S.C. 4201–4245), giving the FWS new authority to ban ivory imports. After the release of the Ivory Trade Review Group's final report (1989), the President decided to halt all African elephant ivory imports. This decision was implemented by the FWS through a total import moratorium on ivory (FWS 1989a). Nearly all other ivory consuming nations also adopted similar import bans. Finally, during their biennial conference in October of 1989, CITES parties decided to ban all commercial trade by listing the African elephant on CITES Appendix I. This ban took effect on 18 January 1990 (FWS 1990a), supplementing the African Elephant Conservation Act import moratorium.

All imports of ivory and commercial imports of other elephant products are now prohibited, except for antiques, certain personal effects, and some trophies. The FWS may issue permits for sport-hunted elephant trophies from African nations which have submitted a trophy export quota to the CITES Secretariat and which have elephant hunting programs promoting conservation of the species (FWS 1990a). Presently, only trophies from Zimbabwe and South Africa are likely to qualify for import permits.

Internationally, the ban appears to have had a beneficial effect; Tanzania's wildlife director, for example, reports that illegal ivory is almost impossible to market in his nation (C. Mlay, Tanzania Wildlife Department, pers. comm.). Japan, with the largest ivory market, and 98 other CITES parties have supported the ban. However, five African CITES nations (Zimbabwe, Botswana, Malawi, Zambia and South Africa), as well as China and the United Kingdom, on behalf of Hong Kong, have taken reservations to the listing (CITES Secretariat pers. comm.). This allows them the option of continuing to trade in ivory among themselves or with non-party nations (such as Taiwan or South Korea), though there is still little market for finished ivory products. South Africa has indicated its intention to apply for return of its elephant population to Appendix II, and other southern African nations may follow later in 1990 (CITES Secretariat pers. comm.). These nations also are proceeding with development of a centralized ivory marketing system (CITES 1990a), and CITES party nations will likely reconsider the ivory issue at their next conference in Japan in 1992.

Another decision pending before the FWS is whether to reclassify the African elephant from threatened to endangered status under the Endangered Species Act, as petitioned by a group of animal protection organizations. The FWS recently announced results of its status review of the species, stating its intention to reclassify all elephant populations to endangered status except those in Zimbabwe, Botswana and South Africa, where they would remain listed as threatened due to their stable populations and effective elephant management programs (FWS 1990c). Publication of the proposal for public comment is expected within 60 days, with a final decision due within one year of the proposal. Final adoption of this proposal would halt all interstate commerce in ivory and would further reduce chances for trophy imports from any but the three threatened populations.

Humane Shipment of Wildlife

The Lacey Act (18 U.S.C. 42 et seq.) is one of the cornerstones of U.S. wildlife law, backing up the wildlife laws of the states and of other nations by making it a Federal offense to transport illegally taken wildlife across state lines or to import it into the United States from another nation. Amendments to the Lacey Act adopted in 1981 (Public Law 97–79) added a new dimension to FWS responsibility by requiring the FWS to ensure humane and healthful conditions of import for wild animals and birds coming into the United States. (Housing and care of mammals already in the United States are regulated by the U.S. Department of Agriculture under the Animal Welfare Act.)

Final implementing regulations for humane transport published in November 1987 (FWS 1987) attempted to build on the provisions of transport guidelines developed by the International Air Transport Association (1987) and CITES (1980). However, immediate concerns were expressed by airlines and wildlife importing industry that some provisions of the regulations were not implementable as written and, in February 1988, the FWS published a notice delaying the effective date (FWS 1988a). A group of animal protection organizations then obtained a court order restoring the regulations until the FWS went through a new process to formally propose revisions. The FWS accordingly began enforcing the regulations judiciously, allowing for exceptions on a case-by-case basis when it could be demonstrated that deviation from their provisions would be advantageous to the wildlife involved (FWS 1988b).

Over the past two years, the FWS has engaged in detailed consultations in preparation for a comprehensive revision to the regulations. CITES nations also adopted new procedures for humane shipment during the 1989 CITES Conference in Lausanne (CITES 1990b). Publication of the proposed revision for public comment is expected later in 1990.

Captive-bred Endangered Species

Section 10 of the Endangered Species Act requires prior issuance of permits for interstate and foreign commerce and import into the United States. These permits are available for scientific research or to enhance the propagation or survival of the species involved, provided the overall action is consistent with the conservation purposes of the act (16 U.S.C. 1539). However, to encourage the use of wildlife already in captivity for propagation and other conservation purposes, the FWS developed a streamlined permit system for captive-bred endangered species (FWS 1979). Qualifying institutions and individuals may obtain a two-year registration if they demonstrate that their proposed activities are consistent with the purposes of the regulation. With the registration, they may then buy and sell animals in interstate commerce, and take, cull and perform other actions consistent with normal animal husbandry, without need for an individual permit for each action.

Over 900 organizations and individuals, including major zoos, circuses, entertainers and hobbyists, are now registered under the system, and it has proven itself to be useful in reducing the paperwork burden on the public. However, some private breeders have argued that the registration system still is serving to discourage small private breeders and that the paperwork requirements could be simplified even more. Others argue that regulation of genetically homogenized captive populations of some species has little conservation value. Thus, in 1987 the FWS began consideration of ways that further deregulation might be accomplished.

However, in the past two years there has been increasing media and public attention about alleged abuses of the system by some entertainers, commercial breeders, and even major zoos (CBS News 1990). These allegations have brought into focus a number of questions about the entire basis for Federal regulation of captive-held, endangered wildlife. Three key issues are (1) determining what conservation purposes are served by regulating captive-held wildlife; (2) establishing what priority should be put into permitting and law enforcement activities; and (3) distinguishing between purely entertainment uses of wildlife, designed solely for profit, and conservation/education uses, whether or not for profit.

In response, the FWS is initiating a further review of its captive-bred wildlife permit program. Substantial public involvement will be sought as the FWS seeks a balance between conservation needs and opportunities, private property rights, and the public attitudes about what are appropriate uses of endangered species in captivity. A *Federal Register* notice on the review is expected later this year.

Marine Mammals

The Marine Mammal Protection Act's regulation of taking, possession and public display of marine mammals is divided between the FWS, for polar bears, walrus, sea otters and manatees, and the National Marine Fisheries Service (NMFS), for seals, dolphins, porpoises and whales. In 1988, in conjunction with reauthorization of the act, Congress adopted a number of amendments (Public Law 100–711) which changed its permit provisions. (Other amendments affecting exemptions for incidental take, preparation of conservation plans for depleted species, reduction of porpoise mortality in tuna fisheries, and studies of dolphin die-offs outside the scope of this paper.)

Section 101(a)(1) of the act was amended to allow issuance of permits for taking and/or importation designed to enhance the survival or recovery of the species, parallelling similar provisions in the Endangered Species Act. Section 104 specifies that such permits are to be issued only if the proposed taking and/or importation contribute significantly to maintaining the distribution or numbers necessary for survival of the species or stock. They must also be consistent with conservation or recovery plans established for the species, if any exist, or with factors which would likely be in any such plans prepared in the future.

More stringent criteria for issuance of permits for public display and for scientific research were established by amendment to section 104(c) of the act. Public display permits may only be issued for use of animals in an overall educational or conservation program accessible to the public. The NMFS and FWS must develop professionally-based standards for all such public display, in consultation with the American Association of Zoological Parks and Aquariums and other organizations. Scientific research permits must be determined to serve a bona fide scientific purpose, and must not involve unnecessary duplication of other research. Before issuing a permit for lethal take of a depleted species for research purposes, there must be determinations that there is no feasible alternative, and that the research will directly benefit the species or stock or will fill a critically important need. In addition, section 104(b) was amended to allow for import of animals which are pregnant, nursing or less than eight months old, to provide for care of orphaned, wounded or sick animals.

The NMFS, which issues many more permits under the act and which is thus more significantly affected by the amendments, has been holding a series of workshops around the country to collect public opinion on their implementation. The FWS has attended these workshops and will use the information and comments obtained during them in development of proposed amendments to its marine mammal permit regulations later this year.

One issue not directly addressed in the 1988 amendments is permits for lethal taking of marine mammals for public display, particularly with reference to import of polar bear trophies from Canada. The FWS had denied such permits in the past where the applicant was not a recognized public institution; this practice, which is not formally addressed in current regulations, will be carefully reviewed as the FWS develops its implementing regulations for the new, stricter permit criteria set up by the amendments.

Resident Species Listed in CITES Appendix II

A number of resident species managed by the states (and in some cases, Indian tribes) are included in CITES Appendix II as species vulnerable to the effects of unrestricted trade, including the lynx (*Lynx canadenis*), bobcat (*Lynx rufus*), river otter (*Lutra canadensis*), Alaskan brown bear (*Ursus arctos*), Alaskan timber wolf (*Canis lupus*), American alligator (*Alligator mississippiensis*) and ginseng (*Panax quinquefolius*). Article IV of the CITES treaty requires that, before the party nation's management authority (in the United States, the FWS) can issue an export permit, it must assure itself that the specimen was legally acquired, and must obtain from the national scientific authority (also the FWS) a finding that the export will not be detrimental to the survival of the species.

Each state seeking to obtain FWS approval for export of Appendix II species must have a management program sufficient to ensure that exports will not be detrimental to the species, under criteria developed by the FWS CITES Scientific Authority (FWS 1984). It must also take steps to ensure that illegal specimens are excluded from entering the trade. Indian nations and tribes seeking export approval must in addition establish that their treaty rights include specific authority for management for the species.

Specific requirements and findings for each regulated species are published in *Federal Register* notices. At one time, all findings were made on an annual basis, but recently, to reduce unnecessary paperwork and burden on the states, the FWS has adopted multi-year findings for lynx, river otter, Alaskan brown bear, and Alaskan gray wolf (FWS 1984), bobcat (FWS 1989b), American alligator (FWS 1989c) and ginseng (FWS 1988c). With the exception of ginseng, all findings now give an open-ended approval for further exports for approved states and Indian nations and tribes unless there is a major change in the program. New findings for animal species in recent years have involved primarily the addition of new states for American alligator exports, a reflection of the continuing recovery of the species, and additional Indian nations and tribes for bobcats. For ginseng, because of difficulties experienced by some states in developing programs, the FWS limited its most recent finding to the three-year period of 1988–1990. Consideration of a longer-term finding will be part of the process developing a new ginseng finding, to be published later in 1990. No major decisions were taken at the October 1989 CITES conference which would materially affect the conduct of these programs, but continued public scrutiny of FWS scientific findings and policies, particularly with respect to furbearers, can be expected.

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Joint State and Federal Investigations

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In 1986, the New Mexico Department of Game and Fish, the Colorado Division of Wildlife, and the U.S. Fish and Wildlife Service (USFWS) embarked on a covert wildlife operation that focused on the commercialization of wildlife parts. The investigation became known as operation "San Luis Valley," or "SLV." As with any covert operation, SLV was initiated because conventional law enforcement methods had failed. Intelligence information was gathered over a five-year period and supplied to investigators in each participating state and the USFWS.

The operation began in Woodland Park, Colorado, and was set up as a small taxidermy, fur-buying and sausage-making business. The company made small fur-buying stops at eight locations in southern Colorado and northern New Mexico. The first illegal purchase of wildlife was not made until after three months of operation. This purchase was for two elk which had been illegally killed in Colorado. As had been anticipated, many illegal purchases would follow over the next two and one-half years. Included in the illegal taking or trade of wildlife were deer, elk, antelope, bobcat, bear, hawks, owls, bald eagles, golden eagles and other protected species. In just over two months, during the fall and winter of 1988, 24 elk, 17 deer, 4 eagles, 5 hawks, 4 owls, 1 antelope, and 1 bobcat were purchased, for a total of 58 animals. The operative soon found that if he didn't purchase the animals they would be sold to other places, although no specific individuals were found or targeted for these purchases. The animals were traded in and out of families, to local restaurants and sometimes traded for drugs.

The business was forced to move twice during the two and one-half years of operation. The first move to Ft. Garland, Colorado, and finally to Costilla, New Mexico. Despite the moves, the business continued to operate and purchase illegal animals. Elk sold for about $150.00 each, antlers for $20.00–$60.00, eagles for $275.00 and owls for $10.00–$20.00. It is important to note here that the price was decided by the sellers and not by the agent. Several times during the operation, individuals stopped by the agent's house to tell him they would get him a certain animal and in short time they would return with that animal. From their conservations with the agent, it is estimated that during the operation over 2,000 deer and 567 elk were poached. In addition to this, 96 bald or golden eagles were killed. Based on these statistics, it becomes quite clear that a market was already established in the area, and no additional market was created by the agent. In fact, the agent had to actually turn down many purchases.

Throughout the operation, it was discovered that there was no real organized group of poachers, but rather a haphazard association of illegal activity. This illegal activity ran into stolen property and drugs as well as illegal game.

The agent's life was threatened during the operation by one of the defendants, Robert Espinoza, who was working as a Deputy Sheriff in Costilla County at the time. Espinoza and the agent had just killed a bull elk and Espinoza, who was wearing a .44 magnum pistol, looked at the agent and asked, "Are you a federal agent? Because if you are, I'm going to kill you." It should also be noted that Espinoza would deal the illegal animals out of his patrol car. He claims he is addicted to poaching just like an addiction to drugs. When he sees a picture of game animals in a book, he has to go kill something. Espinoza is currently serving eight months in a federal prison as a result of SLV.

The investigative portion of SLV concluded in February, 1989, and arrests were made in early March. Due to the precision and care taken by the federal agent, Operation SLV resulted in 57 arrests, 850 charges filed, 22 search warrants served, and 20 vehicles seized. Two hundred seventy-four state and federal officers were used for the arrests. Some say that was too many, but we say that was just enough because the entire procedure went without a hitch. There were no injuries to officers, defendants or their families. When you consider a six-man arrest team, for instance, that had two or three assignments, the procedure went like this. The primary target or defendant was contacted. The team immediately lost two of its members to transport the defendant to jail. The remaining four officers would search the premises and, often times, drive away a seized vehicle. This would then leave three officers to apprehend the team's secondary target or suspect. In several cases, the team would then proceed to a third target or join with another team for execution of a search warrant. Again, let me remind you that the safety of officers, defendants and families was our utmost concern, and only the officers and techniques needed to ensure that safety were utilized.

Following the takedown, the operation was over for many and only beginning for others. Despite efforts to inform the press, many derogatory articles and remarks surfaced. We were accused of excessive force, entrapment and outrageous government conduct. It was said that all of the officers wore camouflage, and wives and children of defendants were terrorized. In addition, congressional hearings were conducted as to the need for such an operation, arrest techniques used, and covert law enforcement activity in general.

Was it all worth it? I think that it was. I say this because, of the 27 New Mexico defendants, all have settled their cases through plea agreements. As a result of this, in addition to fines and jail terms, the courts have required that $6,000 be donated to the state's Operation Game Thief program. Of the remaining Colorado and federal cases, 58 have been settled and only 3 remain.

In terms of simple statistics, the average number of citations written per year in New Mexico is 3,000, or about 60 per officer. The SLV operation, through the use of one agent and support staff, gathered enough information for 850 charges, or 283 citations per year, plus the added advantage of apprehending large-scale commercial dealers of wildlife.

We also learned something about the poachers in that area that I think applies to poachers throughout rural United States. In an interview with a local newspaper, one poacher who sold seven elk carcasses, one elk head and several hides for a total of $1,570 during SLV, said, "I am not a poacher. I've never understood that word. To me, my philosophy is that of a traditional hunter. I was brought up to be a traditional hunter." In spite of the monetary gain, he views himself as taking only the game required for the family larder. Many of the local residents have been brought up this way and are, or were, bringing up their children in the same manner.

Another SLV defendant who testified at the congressional hearings held after the operation, stated that he had always poached and would continue to do so. If this is truly the attitude of the poacher, we in wildlife law enforcement have a rough road ahead. I submit to you that we need active involvement through public affairs, education of citizens, especially youth, and an active law enforcement effort to curtail illegal hunting or commercialization of wildlife.

We can't always tell our story at the time of arrests due to the fact that we are bound legally not to try cases through the press. The press, therefore, hears only one side of the story and subsequently so do the citizens. We had great success with one local newspaper that did a follow-up series after SLV. The result was a six-story series that ran consecutively as headlines for six days. The story tells a pretty unbiased tale of the commercialization of wildlife. Due to this series, operation SLV and another joint state/federal investigation involving the export of New Mexico elk to Canada, commercialization and illegal taking of wildlife may finally get the recognization it deserves. United States Representative Bill Richardson has asked President Bush to consider commercialization of wildlife between the United States and Canada as a topic for the international summit. In addition, Richardson is considering legislation to address poaching, and, I quote, ''given the magnitude of the problem.''

If it weren't for large-scale joint efforts such as SLV, the much needed national attention would be hard to come by. I'm not suggesting that all the national coverage was good, but I do feel we are coming back on track and stand a good chance for progress in the apprehension of commercial wildlife violators.

In this day and time of limited money and manpower, I hope I have shown you an example of what a joint investigation can produce. I'll let you decide if this type of operation will or can work in your state or province. I know they will be continued in New Mexico with the cooperation of Colorado and the USFWS.

Offensive Tactics for Defending Potential Personnel Lawsuits

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This paper will briefly examine procedures which will help law enforcement administrators avoid becoming defendants under the Fair Labor Standards Act (29 USC 201, *et seq.*), Title VII of the 1964 Civil Rights Act (42 USC 2000(e), *et seq.*), and the Age Discrimination in Employment Act (29 USC 631).

There is no absolute protection against an employee or a potential employee instituting a lawsuit under the above Acts, but there are steps to be taken to minimize the possibility of that happening and to maximize the chances that if sued, the results will be favorable toward the public agency.

First and foremost is to recognize and realize that public administration at state and local level is over-watched by federal law, which is enforceable by private actions, class actions, or federal administrative agencies such as the Equal Employment Opportunity Commission. Public administration decisions which may seem logical and necessary to carry out a recognized mission and which, when made, are devoid of any conscious intent to unlawfully discriminate can be used as a basis to claim that hiring or firing practices are in violation of federal statutory or constitutional law and/or that overtime compensation is due to employees because of the number of hours worked. The transformation of the original concept of federalism as a partnership of coequals into today's concept of dominance by the federal government and subjugation by the state and local governments is complete, and those public administrators who do not aggressively seek compliance and enforce compliance with the mandates from Washington, are simply inviting the inevitable lawsuit.

General Considerations

1. Key personnel in administration should become familiar with and stay updated on what is allowed, what is required and what must be done to enforce compliance. Those key personnel could be your administrative officers, your personnel chief, your legal advisor and especially your key subordinates who are charged with participation in personnel management.
2. An intentional shortcut of the requirements of any of these Acts becomes obvious on examination, so do not shortcut the requirements.
3. Contact and utilize specialists (labor lawyers and employment relations specialists) in establishing procedures, policies, testing programs and payment schemes which are governed by these Acts.
4. And, finally, Document! Document! Document!

The federal government, like any government, is an agency that believes in paperwork, and even a court will take cognizance of an attempt to comply with the law if it is well documented.

Fair Labor Standards Act

The thrust of the federal Fair Labor Standards Act is that employees must be given some sort of overtime compensation when their maximum number of hours worked exceeds that which is recognized as the normal work week for that classification of employee. If the maximum number of hours is exceeded, then the employer is required to either (1) pay overtime at one and one-half times the hourly rate; or (2) award compensatory time up to a maximum number of 480 hours. No further compensatory time can be given after the employee reaches 480 hours, and there is no "cut off" period for accumulation of those numbers of compensatory hours. That is to say, the employee continues to accrue overtime *ad infinitum*.

Three questions must be asked by the public agency in dealing with the federal Fair Labor Standards Act:

1. Can the agency support overtime pay? If not . . ..
2. Can the agency support compensatory time? If not . . ..
3. How does the agency insure that only those hours which are authorized to be worked are in fact worked, and therefore limit its financial liability to its employees?

The answer to question one is a function of financial resources of the agency. The answer to question two is dependent on agency personnel resources and agency administration. Most agencies will either pay overtime or allow compensatory time in order to comply with the Fair Labor Standards Act, but in each case the agency will establish a maximum number of hours which may be worked.

The answer to question three poses some management problems for administrators. It is question three that will be addressed.

Any policy which deals with overtime should be a written policy which is distributed to all affected personnel and documentation of that distribution kept in the file. The policy should clearly state the number of hours to be worked in the regular work period; the length of the regular work period, and the number of hours of overtime which may be worked. The policy should provide for a methodology for recording the regular number of hours worked and the allowed overtime hours worked, and must provide that *no unrecorded hours may be worked.* This last proviso creates some protection in the event of a claim for overtime in that in order to prove one is entitled to overtime, the employee/plaintiff must prove that the employer had *actual* or *constructive knowledge* of overtime worked. In an illustrative case, the Fourth Circuit held that where the employer had a written policy which provided that no unrecorded hours could be worked, the plaintiff was unable to prove that the employer had actual or constructive knowledge of overtime worked. *Davis* v. *Food Lion*, 792 F.2d 1274 (4th Cir. 1986). This also puts the burden on the employee to accurately record all hours that he/she puts "on the clock." More importantly, the policy must contain specific information concerning what disciplinary action may result if the policy is violated. Then the policy must be enforced, specifically the disciplinary action. It is indeed ironic that Congress is forcing state administrators to discipline state employees who work too much, but that is how far we have come in the evaluation of the concept of federalism. Bear in mind that the disciplinary action can simply take the form of a written reprimand, but it should be documented; and documented; and documented. It is the documentation of the disciplinary action taken against not only the employee, but the supervising employee who allows it to happen which will eventually help save the agency from a suit under the federal Fair Labor Standards Act.

Title VII—Discrimination Under the 1964 Civil Rights Act

To discriminate or discrimination is defined by Webster as making a distinction; to work or perceive the distinguishing or peculiar features. At one time to assert that someone had discriminating tastes was a compliment to that individual. Today, however, the word discrimination has taken on an ugly connotation and has been overworked as a claim for any perceived wrong, however fanciful. Nevertheless, the federal government has laid a powerful club at the feet of any willing plaintiff's lawyer in Title VII of the 1954 Civil Rights Act and provided an investigative branch of the government to do most of the leg work in the Equal Employment Opportunity Commission (EEOC).

Police administrators who face investigations from EEOC based on an alleged unlawful act of discrimination have to be prepared to overwhelm the investigator with proof positive that there was no discrimination. One of the first things the EEOC investigator will look to is the number of minorities and women employed by the agency. Most agencies who have not been aggressive in recruiting minorities and women do not find themselves overwhelmed with qualified applicants. Consequently, to the EEOC, the lack of employees in the protected classes is an indication that there has been unlawful discrimination. Obviously, the best defense to a Title VII complaint is to have a proportionate number of minorities and women who are satisfied employees and who can deflect the accusations by the potential plaintiff. That being the optimum, it is rarely if ever is the case. As a second defense, administrators need to be able to point to a *documented* aggressive recruiting campaign, for example, letters, advertising brochures, and documented trips to schools, as well as any media campaign that would advertise the desire for minority and female applicants. However, in hiring, agencies must exercise extreme caution that minorities and women are not hired over a more qualified applicant. Otherwise, you may face a "reverse" discrimination suit by a disappointed applicant.

Recently, in a decision which signals some form of logical approach to a Title VII complaint, the United States Supreme Court said that racial imbalance in one segment of an employer's work force is not sufficient to establish a *prima facie* case of disparate impact if the absence of minorities in that area of the work force was due to a lack of qualified minorities for reasons that are not the fault of the employer. *Wards Cove Packing Company* v. *Atonio*, 490 U.S. ____, 140 L.Ed.2d 733, 109 S.Ct. ____(1989). In other words, simply because the numbers do not show minority employment does not necessarily mean that the selection process is discriminatory if the employer can show the reason the minorities were not employed was because there was a lack of qualified applicants. For example, if you employ 100 conservation officers and only 2 are women, the figure that EEOC will latch onto is 2 percent. However, if of the qualified applicants for the job there were only 20 women, by hiring 2, you have hired 10 percent of the qualified applicants.

Administrators who face discrimination charges are at first shocked by the fact that employees and potential employees who are only minimally qualified for a position can bring the full might of the federal government to test and administrative decision on who should be hired or promoted, when the administrator is looking for the best person to fill the job. Unfortunately, for the administrator all the potential plaintiff has to show to establish a *prima facie* case is that the plaintiff is: (1) within a protected class (racial or ethnic minority or female), (2) applied for a job for which the employer was seeking applicants, (3) was qualified to perform the job, (4) was denied the job, and (5) the employer continued to seek applicants for this position (*McDonald Douglas Corporation* v. *Green*, 411 U.S. 792, 36 L.Ed.2d 668, 93 S.Ct. 1817 [1973]). The only one of these criteria over which the defendant exercises any amount of control is "qualifications to perform the job." On first blush, this seems to be the solution to many of the problems. Simply establish employment criteria which of themselves eliminate all except the best candidates. Not so fast. The Supreme Court has also pronounced in *Grigg* v. *Duke Power Company*, 401 U.S. 424, 28 L.Ed.2d 158, 91 S.Ct. 849 (1971) that if criteria for employment, although facially neutral have the effect of discrimination, then those are also improper. According to the Supreme Court, the Act proscribes not only overt discrimination, but also practices that are fair in form but discriminatory in operation. The Court then went on to say that in order for criteria to be valid, there must be a manifest relationship to the employment in question.

The question then becomes is how to design hiring criteria which will produce the best candidate, but at the same time have a provable relationship to the job in question so that it will withstand any challenge as discriminatory.

One suggested way is to include an overly detailed job description in each position announcement. If applicable, the level of education such as high school, two years of college, four years of college should be included along with any educational requirements for promotion in this career field. This is particularly true if the job opening is at the lowest level and there is a potential for career development. In other words, the job announcement should include something like "this entry level position will require the successful applicant to perform work which is commensurate with having a high school diploma; advancement in this career field will require the applicant to possess skills normally associated with two years of college or greater." Similarly any physical requirements such as prolonged exposure to weather, night work, ability to negotiate rugged terrain, and/or ability to life and carry objects such as a deer or bear carcass should be detailed in the job announcement. In any event, announced position requirements should be *demonstrably related to the particular position*. Even if a particular criteria has the effect, although unintended, of excluding minority applicants, it may still be used as a valid criteria if it is manifestly related to job performance.

The EEOC has published guidelines which are designed to assist employers in complying with the requirements of the federal law prohibiting discriminatory employment practices. (See 29 C.F.R. 1607, *et seq.*) The guidelines apply to test and other selection procedures which are used as a basis for any employment decision, including hiring, promotion, demotion, and retention. It would be logical and very convenient for employers if by following these employment guidelines, employers could assure themselves that there would be no successful challenges to their practices; however, such is not the case because EEOC will not given your employment practices a "good housekeeping seal of approval" based on the employment guidelines. It is beneficial though to have the employment practices validated using these guidelines, so that a court can be convinced at least of a good faith effort.

One very notable part of the guidelines (1607.15[A][3]) underscores the need to document each step taken in employment practices. That section lists various types of documentation evidence which should be obtained or maintained to support the validity of the employment practices.

Title VII of the 1964 Civil Rights Act is a powerful sword for potential employees and employees who become dissatisfied because of either real or imagined acts of unlawful discrimination. Documentation is the first line of defense in any of these cases.

Age Discrimination in Employment Act

The Age Discrimination in Employment Act (29 U.S.C. 631) protects individuals who are at least 40 years of age against all forms of employment discrimination, not just in hiring and mandatory retirement. For example, it is a violation of the Act to discriminate by age in wage benefits, hours worked or availability of overtime.

As in the Title VII cases, the plaintiff carries the burden of establishing a prima facie case, and then the burden shifts to the defendant to explain that the action taken was not unlawfully based on age, but some other factor. Age can be considered in mandatory discharge cases if the defendant is prepared to prove that age is a bona fide occupational qualification reasonably necessary to the normal operation of the particular business. That is, if the employer has reasonable cause for believing that all or substantially all persons within a class would be unable to perform safely and efficiently the duties of the job involved, or that it is impossible or impractical to deal with persons over the age limit on an individual basis (*Arritt* v. *Grisell*, 567 F.2d 1267 [4th Cir. 1977]).

On November 1, 1986, President Reagan signed amendments to the Age Discrimination Employment Act. Those amendments, among other things created a specific exemption which will permit state and local governments which has a mandatory retirement law or a maximum hiring age law for law enforcement officers or fire fighters in effect on March 3, 1983 to continue to enforce those laws.

This does not allow an agency which had a policy or law in effect on March 3, 1983, but *which has not consistently applied those laws or regulations to begin applying the law and regulation and thus mandatorily retiring an individual*. Likewise, it does not allow an agency which had no law or policy in effect on that data to now institute such a policy or law.

However, an agency which wants to establish a mandatory retirement age may be able to do so by conducting studies which will prove that being below a certain age is a necessary requirement for successfully performing a particular job. This is often done by showing the correlation between decline in physical abilities with increase in age. Amazingly, the federal courts occasionally realize that as human beings reach older ages, their physical abilities decline. But establishing age as a bona fide occupational qualification (BFOQ) is expensive and does not preclude the law suit. In fact, establishing a mandatory retirement age after March 3, 1983, or enforcing a previously unenforced retirement age is an invitation to a lawsuit.

A better course of action may be to establish physical fitness requirements (which do not discriminate and therefore run afoul of Title VII) for wildlife conservation officers. In the case of *United States. v. Wichita Falls*, 47 FEP Cases 1629 (N.D.Tx.

1988), the District Court in Texas found that the Wichita Falls' police department's physical assessment and physical ability test was necessary to be an effective police officer in Wichita Falls, Texas. The physical assessment test was used to screen applicants for entry into the police academy, and applicants who were successful were to pass a more strenuous physical ability test after they had undergone some training at the police academy. In analyzing a physical agility test, one court has given some very sage advice to police administrators. In *Thomas* v. *City of Evanston*, 610 F.2d 422 (D.C. Ill. 1985) the court said, "too often tests which on the surface appear objective and scientific, turn out to be based on ingrained stereotypes and speculatively assumptions about what is "necessary" to the job. Thus, tests which discriminate against protected groups must be thoroughly documented and validated in order to minimize the risk of unwarranted discrimination . . . ."

However, one of the easiest and most effective defenses against the age discrimination in employment case is simply not tolerating lackadaisical performance because of physical inability to do the job. Agencies which have mandatory retirement laws and which base these retirements on physical attributes necessary to job performance, may be jeopardizing age as a BFOQ if they allow employees in that category who cannot or will not maintain physical fitness to stay on the job or return to work after suffering a debilitating injury or heart attack.

This appears to be a very harsh and unbending rule, however, agencies cannot have it both ways—either it takes considerable physical stamina which must be maintained regardless of age, to perform the job of a law enforcement officer, or our stereotype thinking needs to be readjusted. Age discrimination cases are best defended by personnel evaluations that will document the decline in performance or physical ability to do the job. That type administrative decision is one of the toughest for any police administrator, but such is necessary under the watchful eye of federal employment law.

Special Session 6. *Managing Western Water*

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An Update on Legal Issues

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Introduction

When considering the needs of fish and wildlife for water—minimum flows in streams and provision of healthy habitat—the legal structure of water rights and the activities of water project developers have consistently been at cross purposes with these needs.

State Water Rights Systems

State water rights system in the Western United States developed primarily from the law of property, and more specifically, from the "first-in-time, first-in-right" concept of mining claims. These systems were designed to promote economic development. They did not account for fish and wildlife needs in two principal ways. First, the system merely dealt with the relative rights of consumptive users. Second, for many years when the states were involved in allocating water under these systems, little recognition was given to protection of nonuser rights, such as fish and wildlife. When this recognition finally came, through the imposition of "public interest" conditions on new water rights, these new conditions seldom affected prior users whose older rights had "vested." This was complicated by the fact that many streams have already been fully appropriated. The California State Water Resources Control Board recently issued a finding that hundreds of streams in California are fully appropriated, especially at critical low flow times of year.[1]

Federal Activities

Federal water project development has taken place for most of this century. In addition to the water supply projects of the Bureau of Reclamation, many streams

[1]California, State Water Resources Control Board, *Order WR 89-25* (November 16, 1989)

have been dammed by U.S. Army Corps of Engineer's flood control projects. Other agencies, such as the Soil Conservation Service, have been responsible for many water projects, usually smaller ones. In the regulatory area, since 1920 the U.S. has been licensing power projects built by non-federal interests under the Federal Power Act.[2] In both its construction and regulatory roles, the federal government has been slow in many respects to recognize the needs of fish and wildlife. The Fish and Wildlife Coordination Act[3] provides that fish and wildlife concerns are to be given "equal consideration" with other project purposes, but its effectiveness has been limited by ineffective means of enforcement.

Congress, however, recently enacted the "Electric Consumers Protection Act of 1986" which amended the Federal Power Act to require the Federal Energy Regulatory Commission (FERC) to give equal consideration to non-power values. These include fish and wildlife and recreation. Under this law federal and state wildlife agencies will be able to set binding protective conditions on projects.[4]

Current Federal Issues

Compliance with State Water Rights Laws

In 1978, the United States Supreme Court, in *California* v. *U.S.*,[5] changed decades of legal understanding and reinterpreted section 8 of the Reclamation Act of 1902 to hold that federal water projects must comply with state water rights laws unless there was a "clear congressional directive" to the contrary.

This case originated in California where an environmentally sensitive water rights administration had been pushing the Bureau of Reclamation from the early 1960s to comply with state water rights laws, particularly those involving the release of stored water to provide outflow through the Sacramento-San Joaquin Delta. One of the main purposes of such outflow (which, in part would mitigate prior historic reductions in flow) was for fish (bass, salmon and resident fish) and wildlife (the Suisun Marsh adjacent to the Delta is a major part of the Pacific Flyway).

The Federal Power Act of 1920 has a provision similar to Section 2 of the Reclamation Act which state water administrators believe should be interpreted in the same manner as the Reclamation Act[6] by requiring FERC to comply with state water rights laws in issuing federal licenses. However, in 1946, the U.S. Supreme Court, in *First Iowa Hydro-Electric Cooperative* v. *Federal Power Commission*,[7] held that this was not required.

For many years lawsuits have been brought arguing that this issue should be revisited by the Supreme Court, which it will be this term in the case of *California* v. *FERC*.[8] The trial court and the Ninth Circuit in that case declined to make a drastic change in the law, in light of *First Iowa*.

[2] 16 U.S.C. § 791(a) et. seq.

[3] 16 U.S.C. § 661 et. seq.

[4] 16 U.S.C. § 824a-3.

[5] 438 U.S. 645 (1978).

[6] 16 U.S.C. § 821.

[7] 328 U.S. 645 (1946).

[8] 877 F. 2d 743 (9 Cir) *Cert. granted* 110 S. Ct. 537 (1989).

The project in question in *California* v. *FERC* is a small hydro project and the issue is minimum flows for fish. This lawsuit (which 43 states joined with California in asking the Court to hear) is interesting in that the State and various environmental groups are on the same side. The Sierra Club's position, for example, is that both state and federal rules should apply, with the one providing the most flows prevailing. Inevitably a state may decide not to issue a water right for a damaging power project. This is where the issue is most critical. Will the Supreme Court permit a state to veto a power project that the FERC would otherwise license? Since the Congress does not deal with FERC projects in the same manner as it authorizes federal water projects, the escape hatch of the "clear congressional directive" is not there. The Supreme Court has been reluctant to give states a veto over the federal government but in recent years Congress has specifically authorized states to impose substantive and procedural requirements on the federal government itself under the Clean Water Act[9] and the Clean Air Act.[10]

Restoration of the San Joaquin River Fisheries

In the 1950s, the U.S. Bureau of Reclamation constructed Friant Dam on the San Joaquin River as part of the Central Valley Project. The result of this dam is well known: the destruction of the fisheries (both the spring and fall salmon runs) of the river. There were virtually no minimum flows provided past the dam. This effect was felt all the way to the sea. Unfortunately, in 1959, the California State Water Rights Board found the destruction of fisheries was in the "public interest."[11] How times have changed!

Dozens of water service contracts were signed with irrigation districts for water from Friant Dam and the Central Valley Project. These contracts are now coming up for renewal and there is a golden opportunity to make amends for the single-purpose decisions of the past.

Water contractors want these contracts renewed on their same terms with the same amount of water. If minimum flows are to be restored to the San Joaquin, however, some previously contracted water must be dedicated for this purpose. Environmental groups have insisted that environmental impact statements under the National Environmental Policy Act[12] be prepared for the contracts.

Secretary of the Interior Manuel Lujan initially determined to forge ahead without environmental documentation, execute new contracts, and turn his back on rectifying the obvious mistakes of the past. In response to protest by the Environmental Protection Agency and the Council on Environmental Quality, he announced contracting will to go ahead, but an environmental impact statement on Central Valley water problems will follow. Fortunately, his may not be the last word. A lawsuit has been filed in Federal District Court in Sacramento over the environmental impact issue.[13] The irrigators who have enjoyed cheap water with no environmental strings attached

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[9]33 U.S.C. § 1323.

[10]42 U.S.C. § 6991f.

[11]California, Water Rights Board. *Decision D. 935* (June 2, 1959).

[12]42 U.S.C. §§ 4321 et. seq.

[13]*National Resources Defense Council* v. *Hancock*, Civ. S-88-16589-LKK (ED, CA).

for years have a powerful lobby in Washington. But the Courts may have a significant role to play as to this issue.

A second possible means of restoring the San Joaquin, is action by the State Water Resources Control Board. The San Joaquin River flows northward to its confluence with the Sacramento River in the Sacramento-San Joaquin Delta. Under California law, upstream diverters can be required to release stored water to meet the needs of the delta, including fish and wildlife.[14] The Board is currently in the midst of a major review of water rights and the delta. It should not hesitate to require the Bureau of Reclamation and other longtime upstream holders of water rights on tributaries to the delta to contribute to the solution to the delta's water problems by releasing water for this purpose.

Federal Reserved Water Rights

When the U.S. Supreme Court recognized federal Reserved Water Rights in 1963 in *Arizona* v. *California*,[15] it seemed that the federal government would be able to meet fish and wildlife needs in part through assertions of reserved rights. The states objected to the decision as an interference with state water rights. In 1978, on the same day the Supreme Court recognized the state concerns and limited the scope of reserved rights in *U.S.* v. *New Mexico*.[16] There continues to be much litigation over reserved rights as stream by stream, the federal government strives to make the most of this source of fish and wildlife water supply.

Current State Issues

Certain trends are illustrated by the following selected state statutes and court decisions.

Changing State Water Rights Laws

State laws are gradually changing to reflect a greater concern for fish, wildlife and environmental needs. More than 70 years ago California law specifically provided for consideration of the public interest in the issuance of water rights.[17] However, it was not until the last 25 years that this consideration has meant affirmative consideration of fish and wildlife needs.

An example of these winds of change has taken place in New Mexico. As a result of a court decision involving export of ground water to Texas, conservation and public welfare considerations were required in the state engineer's consideration of ground water diversions.[18] The legislature responded in 1985 by requiring consideration of the public welfare and conservation in all actions on new water rights and transfers of existing rights-surface and ground water.[19] However, a recent decision

[14]See *United States* v. *State Water Resources Control Board*, (1986) 182 Cal. App. 3d 82, at 125, 129–130.

[15]373 U.S. 546 (1963).

[16]438 U.S. 696 (1978).

[17]Ch. 133, [1917] Cal. Stat. 194.

[18]*City of El Paso* v. *Reynolds*, 597 F. Supp. 694 (D.N.M. 1984).

[19]See 1985 N.M. Laws, ch. 201.

of the New Mexico Court of Appeals gave a somewhat restrictive reading to the public interest concept.[20]

The Montana Supreme Court in *Matter of the Adjudication of the Dearborn Drainage Area,*[21] expanded the concept of recreation and fish and wildlife as beneficial uses.

The Colorado Legislature followed several other western states and enacted minimum streamflow legislation in 1986.[22] Projects requiring federal approval must submit fish and wildlife mitigation plans to the Water Conservation Board for approval.[23]

The same year, the Wyoming Legislature passed instream flow legislation, including the designation of instream flows as beneficial uses.[24]

These late-coming statutes always promise more than they deliver because they seldom affect vested rights. Often they apply only to new applications. Many times the state must purchase rights or find those willing to donate rights. Sometimes, only certain streams are affected by new laws. Nevertheless, progress is being made in recognizing fish and wildlife and environmental values in traditional western water rights.

State progress in dealing with these issues has been partly in response to federal environmental requirements being placed on projects also subject to state water rights. The Corps of Engineers' permit program under Section 404 of the Clean Water Act[25] has caused resentment by the states as interfering with state water rights administration. Yet the problems have not been great in states that recognize fish, wildlife and environmental needs. The biggest conflicts have come in states whose laws give little or no recognition to environmental and fish wildlife values. In this instance, unlike the Bureau of Reclamation on California's San Joaquin River, the federal government is a positive force in protecting fish and wildlife values. When the state does not want to impose conditions for the protection of fish and wildlife, the federal government often does.

After the landmark public trust case in California, *National Audubon Society* v. *Superior Court,*[26] other states such as Idaho[27] and North Dakota[28] have recognized the public trust. While some cases did not directly involve water rights, this is doubtless a growing area of the law.

Federal Riparian Rights

With limits on federal reserved rights, the federal government in California claimed federal riparian rights. California, of all the western states, recognized riparian rights.

[20]*In the Matter of Howard Sleeper,* 107 N.M. 494,. 760 (1988).

[21]45 Mont. St. Rep. 1948 (1988).

[22]Colo. Rev. Stat. § 37-92-102(3).

[23]Colo. Rev. Stat. § 37-60-122.2(2)(b).

[24]Wyo. Stat. §§ 41-3-1011 et seq.

[25]33 U.S.C. § 1344. This dredge and fill regulatory statute has been interpreted to require permits for filling of wetlands involving all the surface waters of the U.S. Regulations are found at 33 CFR § 323.1 et. seq.

[26](1983) 33 Cal. 3d 419, *cert. denied,* 464 U.S. 977 (1983)

[27]*See,* for example, *Shokal* v. *Dunn,* 109 Idaho 330 (1985).

[28]*See,* for example, *Bottineau County Water Resource District* v. *North Dakota Wildlife Society,* 424 N.W. 2d 894 (N.D. 1988)

These rights attach to land adjacent to a stream and have one unusual aspect—they are not lost by non-use. (Although when a stream is fully appropriated, *unused* riparian rights can be given lowest priority.[29]

The California Supreme Court in *In re Determination of Rights to Water of Hallett Creek Stream System*,[30] held that *under state law*, the federal government has riparian rights on federal lands in California. Whether this decision will have any practical effect remains to be seen. In most California streams the critical flow times are summer and fall when natural flows are lowest (and riparian rights least available). Yet, this is another possible means of providing flows for fish, wildlife and environmental needs through existing legal systems.

Conclusion

It is clear that the needs of fish and wildlife are not yet fully met by federal and state legal systems. Yet, it is equally clear that there is no single answer to meeting this need. Neither the states nor the federal government in all circumstances provide the best programs to meet these needs. There is much to be done to ''modernize'' state water rights laws to provide an appropriate level of protection and enhancement for fish and wildlife. The federal government needs to fill the gaps left by limitations on reserved rights, and it must do a better job of considering fish and wildlife in its own projects.

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[29] *In re Waters of Long Valley Creek Stream System* (1979), 25 Cal.3d.339.

[30] (1988) 44 Cal. 3d 448, *cert. denied sub nom California* v. *United States*, 109 S. Ct. 71 (1988).

The Economic Value of Water to Wildlife and Fisheries in the San Joaquin Valley: Results of a Simulated Voter Referendum

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Wildlife and Fisheries Values at Risk in California's San Joaquin Valley

This study's primary objective is to develop information on the economic value to society from resolving fish and wildlife resource problems associated with water quantity and quality (e.g., agricultural drainage) in the San Joaquin Valley. The San Joaquin Valley (SJV) is important wildlife habitat and supported an estimated 2 million birds during the mid-1970s (Jones and Stokes Associates 1989:2). About one-third of the entire Pacific Flyway's wintering waterfowl population resides in the SJV. The actual breeding waterfowl populations are only a portion of this, but the SJV still makes an important contribution to the flyway population, especially for certain species (Jones and Stokes Associates 1989:2). The SJV supports about 90,000 acres of seasonal and permanent wetlands, with a majority of this being on private lands. These remaining wetlands represent about 10 percent of what was originally wetlands in the SJV (Frayer et al. 1989:17).

Much of remaining wetlands have only about 25 percent of the water required under optimum management (U.S. Bureau of Reclamation 1987:S-3). As is common practice in other areas of irrigated agriculture in the West, some of the water received by refuges and wildlife areas is agricultural drainage water. Agricultural drainage water contains high levels of selenium, boron, arsenic and other trace elements which are concentrated to hazardous levels. Since the Federal Government required farmers to stop discharging agricultural drainage water to Kesterson, farmers have been increasing their use of on-farm evaporation ponds. Such evaporation ponds act as a conduit to biomagnify these trace elements in waterbird populations. As an attractive nuisance to wildlife, these evaporation ponds may become "population sinks" which attract birds that subsequently become incapable of reproducing successfully and may experience high levels of mortality (Jones and Stokes Associates 1989:9).

Last, the SJV contains the San Joaquin River, which prior to the mid-1940s supported naturally spawning stocks of chinook salmon. The construction of Friant Dam and reduced river flows have resulted in near elimination of the chinook salmon fishery in the San Joaquin River. This paper presents the economic value to society from reversing many of these adverse conditions experienced by fish and wildlife in the San Joaquin Valley.

Study Methodology

Since the objectives of this study include measurement of the economic value to society of fish and wildlife in the San Joaquin Valley, it is important to define the types of economic benefits to be measured. Loomis et al. (1984) relate the concept of Public Trust values and environmental values to Randall and Stoll's (1983) notion of "total economic value." In particular, total economic value is made up of five components: (1) onsite recreation use of the resource, (2) commercial use of resources, (3) an option demand to maintain the potential to visit the resource in the future, (4) an existence value derived from simply knowing the resource exists in a preserved state and (5) a bequest value derived by individuals from knowing that future generations will be able to enjoy existence or use of a resource.

To quantify "total economic value" requires measurement of an individual's maximum willingness to pay (WTP) or minimum willingness to accept for alternative levels of fish and wildlife in the San Joaquin Valley. An increase in fish and wildlife to higher population levels than is present today can be viewed as an increment in a person's well being or utility. As such, willingness to pay could be argued to be the appropriate measure.

Techniques for Measuring Willingness to Pay

The Contingent Value Method (CVM) is the technique best able to measure California residents' willingness to pay for different levels of wildlife management in the San Joaquin Valley. CVM is a widely accepted method for valuing both recreation and other nonmarketed benefits of environmental resources (*see* Cummings et al. 1985). CVM has been recommended twice by the U.S. Water Resources Council (1979, 1983) under two different Administrations as one of two preferred methods for valuing outdoor recreation in Federal benefit-cost analyses. Recently, the U.S. Department of Interior (1986) endorsed CVM as one of the two preferred methods for valuing natural resource damages. CVM is capable of not only measuring the valuing of outdoor recreation but is the only method available to measure other resource values such as option, existence and bequest.

The original concept underlying CVM is that a realistic but hypothetical market for "buying" use and/or preservation of a nonmarketed natural resource is described to an individual. Then the individual is told to use this market to express his or her valuation of the resource. Recently, a dichotomous choice or "referendum" approach has been developed where the respondents answer "yes" or "no" to one randomly assigned dollar amount chosen by the interviewer. For more details on these three approaches, *see* Cummings et al. (1986), Hanemann (1984), and Kriesel and Randall (1986).

There are several advantages to using the dichotomous choice referendum approach in this study. First, a pretest indicated that people perceived a need for *social* rather than individual action to correct the many threats to wildlife, fish and their habitats in the San Joaquin Valley. Therefore, respondents felt a voter referendum format was more credible than a market format. This voter referendum format is similar to the successful Proposition 70 (wildlife, open space and parks bond) on the June 1987 ballot. This proposition asked voters to approve a bond issue for the purchase of habitat and open space in California. The bond funding would be repaid from state tax monies. The referendum format is similar to how state residents make decisions on many environmental programs such as clean water, pesticides or recreation areas. The voter referendum format avoids making the CVM sound like a solicitation for charitable contributions.

As Kriesel and Randall (1986) indicate, the dichotomous choice approach to CVM is structured such that the individual's best response strategy is to tell the truth. Since the referendum format is dichotomous choice, the individual must only determine if their value is greater than or less than the dollar amount they are asked to pay. This is simpler than having to state exactly what is their WTP. Because it was necessary to ask a total of 11 WTP questions in the survey, the partical advantage to the respondent of the dichotomous choice format is especially apparent. It is only feasible to ask respondents to answer this many questions if a close-ended, yes/no format is used. Asking this many open-ended or iterative questions would have placed too much of a burden on respondents.

The means of paying for the good in the survey must be realistic and as neutral as possible for the respondent. To improve realism, the payment vehicle should be appropriate for the resource and market constructed. Given the political ''market'', i.e., the voter referendum, the use of additional taxes was realistic and credible. While some people may react emotionally to this issue, we can ascertain if this is a problem using a protest check question. In addition, the focus groups used to develop the survey indicated that additional taxes was a realistic and acceptable payment vehicle.

Methods

To estimate WTP from yes/no responses to different dollar amounts requires two steps. The first step is to statistically estimate a logistic regression of the general form:

$$(1)\ YPAY = Bo - B_1(\$Ti)$$

where YPAY = one if respondent said yes would pay, and zero if said no, and Ti = the increase in taxes the respondent is asked to pay. The next step is to compute WTP from the logit equation. This is basically the area under the logit curve or the expected value of WTP (i.e., the probability a person would pay each dollar amount times the respective dollar amount). Following Hanemann (1989) WTP is given by:

$$(2)\ WTP = (1/B_1) * \ln(1 + \exp^{Bo})$$

Survey Design

The basic survey booklet and interview involves an introductory set of questions about wildlife, followed by WTP questions, and ending with demographic questions about the respondent. The final multi-color survey booklet sent out was the result of three focus groups and a pretest.

There were four major sections of the survey. The first was entitled "Wildlife and You." This section included questions about the importance of fish and wildlife, whether the respondent had visited the San Joaquin Valley, and if so, for what purpose. Additional questions were asked to determine the respondents' familiarity about fish and wildlife issues the San Joaquin Valley. Next, was a series of attitude questions about threats to fish and wildlife and importance of wildlife species. These questions also provide some non-monetary indicators of importance of wildlife and to let the respondent begin thinking about wildlife issues. In addition we inquire about their motivations for protecting wetlands, wildlife and fisheries resources.

The next major section of the questionnaire, entitled "Alternative Futures," described alternative fish and wildlife programs that could be implemented in the San Joaquin Valley. The issues were set up as a vote on a referendum regarding each resource issue and level of management. The individual was asked to vote on three programs, with two of the programs having two alternative levels of management intensity. Thus a person voted a total of five times. Last, a check question was asked to determine whether any "no, would not pay" responses were protest to some feature of the referendum.,

The specific programs people voted included a Wetlands Habitat and Wildlife Program which provided three alternative levels (a no action, a maintenance and an improvement level) of three key characteristics: (1) wetland acreage, (2) resident waterbirds and wintering waterfowl, and (3) public viewing of wildlife. The three levels for wetlands involved a loss down to 27,000 acres in SJV, a maintenance of the current 85,000 acres, and finally an improvement to 125,000 acres. The improvement level involved purchase of additional wetlands and required water supply. With regard to bird populations, the relative percentage decreases in resident and wintering species under the no action alternative (approximately a −70 percent loss) and the percentage increase of both groups of species with the improvement program (+40 percent) were illustrated using bar charts.

The Wildlife Contamination Control Program provided three alternative levels for two key indicators: (1) percentage resident waterbird exposure to contaminated waters; (2) cases of reproductive failure in the valleys' nesting waterbirds. The no action level involved 95 percent of the SJV's resident water birds being exposed to contaminated water. The maintenance program involved 70 percent exposure, while the improvement program resulted in only 20 percent of SJV's resident water birds being exposed to contamination. This was represented by color charts in the survey.

The San Joaquin River and Salmon Improvement Program involved comparison of the no action level and an improvement level for two key indicators: (1) chinook salmon populations and (2) sport and commercial catch of chinook salmon. The two alternative levels were illustrated graphically.

The particular contamination and wildlife levels chosen for program were developed jointly by biologists with Jones and Stokes Associates, U.S. Fish and Wildlife Service, Bureau of Reclamation and California Department of Fish and Game. For details, *see* Jones and Stokes Associates (1989).

The exact wording of the question sequence for Wetland Maintenance is: "If the Maintenance program were the only program you had an opportunity to vote on, and it cost every household in California $T dollars each year in additional taxes would you vote for it? YES or NO."

The follow up telephone question was set up as follows: If they said NO to $T dollars, they were asked "What if the cost were ½ $T, how would you vote then. If they had said YES to $T, they were asked how they would vote at two times $T. The range of the dollar bid amounts was $30 to $130 for the maintenance questions and $45 to $225 for the improvement questions. The followup vote at ½ $T or twice $T involves a double bounded logit which proved to increase the precision of WTP significantly (Hanemann et al., unpublished)

This basic question format was also asked for the Wetlands Improvement program, Wildlife Contamination Control Maintenance and Improvement programs, and a San Joaquin River and Salmon Improvement Program. Five votes were asked with this format. The resulting benefit estimates reflect annual household total WTP (Randall and Stoll 1983, Loomis et al. 1984).

Data Collection and Data Sources

The data collection procedure used in this study involved a combination of mailing a survey booklet to the respondent and then conducting the interview over the phone. Specifically, the actual interview and data collection from the respondent took place over the telephone. However, the respondent did have a survey booklet in front of them at the time of the interview.

Initial phone calls were made to random samples of households in the San Joaquin Valley and the rest of California to solicit their participation in the study. A total 1,573 households were scheduled for interviews for a participation rate of 63 percent. Of these 991 households, 803 (227 in the San Joaquin Valley and 576 in the rest of California) completed the interview when called back after receiving the survey booklet. This represents an overall completion rate of 51 percent for both steps.

Results

Reduced Protest Responses with Voter Referendum Format

As is normal for all CVM studies, the completed questionnaires were screened for protest responses to the willingness to pay question. The voter referendum format had a very low percentage of respondents protest the WTP questions. Only 4.5 percent of the respondents voted against all programs because they either felt the referendum was unrealistic, that government waste money, they already paid enough in taxes or that others (e.g., farmers or visitors) should pay. This protest rate is substantially below the 10–23 percent protest rates found by Walsh et al. (1984, 1985), who used a payment into a trust fund approach in Colorado. This protest rate is much lower than found by Loomis (1987) using both a trust fund and water bill for preservation of Mono Lake. Thus the voter referendum format seems to have a greater credibility with the general public than other approaches. However, more comparisons are needed before any final conclusions can be drawn.

Table 1 presents the logit equations estimated using the double bound approach for both residents of the San Joaquin Valley and the rest of California. As Table 1 illustrates, all of the slope coefficients in the logit equations are statistically significant at the 1 percent level.

Table 1 also presents the benefit estimates (net WTP) for both residents of the San Joaquin Valley and rest of California. These benefit estimates conform to eco-

Table 1. Double bound logit equations and benefits per household.

Program/Location	Logit equation Intercept	Logit equation Slope	Benefit estimates Mean	Benefit estimates 90% C.I.
Wetland maintenance				
California	3.77	−0.0249	$152	123–188
(T statistics)	(16.74)	(−13.94)		
San Joaquin Valley	3.80	−0.022	$174	157–196
	(9.88)	(−7.52)		
Wetland improvement				
California	3.042	−0.0123	$251	235–268
	(17.73)	(−14.75)		
San Joaquin Valley	2.80	−0.010	$286	255–325
	(10.08)	(−8.27)		
Contamination maintenance				
California	3.61	−0.0194	$187	177–199
	(17.49)	(−14.57)		
San Joaquin Valley	3.65	−0.0187	$197	179–216
	(12.05)	(−9.63)		
Contamination improvement				
California	2.87	−0.0095	$308	289–331
	(17.74)	(−14.86)		
San Joaquin Valley	2.434	−0.0070	$360	317–415
	(9.77)	(−8.14)		
Salmon improvement				
California	3.450	−0.0192	$181	171–193
	(16.85)	(−14.04)		
San Joaquin Valley	3.10	−0.0156	$202	180–231
	(10.16)	(−7.81)		

nomic theory. The net WTP for the improvement level programs is higher than for the maintenance level. In addition, the gain in WTP going from maintenance to improvement is smaller than going from no action to maintenance level. There is, as theory would predict, diminishing marginal value of additional wildlife habitat improvements. The benefit estimates are about the same magnitude as a dichotomous choice CVM survey of California households for protection of wildlife habitat at Mono Lake (Loomis 1987).

The confidence intervals were calculated using Park et al.'s (1989) adaptation of Krinksy and Robb's (1986) technique for calculating confidence intervals for elasticities. This approach involves three steps: (1) a multivariate normal distribution for the estimated parameters is constructed having as its mean the parameter estimates, and having its variance developed from the parameter's variance-covariance matrix. (2) a large number of draws (here 4,000) are made from the resulting multivariate normal distribution. At each draw, the resulting parameters are used to calculate WTP; (3) The vector of WTP are ranked and 5 percent of the WTP estimates in each tail are dropped to form a 90 percent confidence interval on WTP.

These confidence intervals demonstrate that benefits do rise in a statistically significant manner as wildlife management moves from the maintenance to the improvement level. The confidence intervals also show the relatively high degree of precision in these benefit estimates. Nearly all of the 90 percent confidence intervals are within plus or minus 10 percent of the mean.

Population Estimates of WTP for Improving Fish and Wildlife in the SJV

These average values per household must be expanded upward to the number of households statewide in California. The accuracy of expanding a sample to the population is dependent upon the representativeness of the sample. While the original sample was a representative sample of California residents, the 51 percent response rate is somewhat lower than desirable. However, the sample appears to represent many of the key socieconomic characteristics of the state population fairly well.

Therefore our best estimate of statewide benefits is obtained by multiplying our sample value per household by the total number of households in California. This involves weighting households in SJV by 0.09 and rest of California by 0.91, their respective representations in the population. Aggregate benefits are given in Table 2 for the State of California. One could compute a lower bound benefit estimate from the figures in Table 2, by assuming (we believe somewhat incorrectly) that the nonrespondents to the survey had a zero WTP. In essence the conservative lower bound values then would be half the numbers reported in Table 2.

As the results in Table 2 indicate, the benefits are $3 billion for reducing the percentage of waterbirds exposed to contamination from 95 percent to 20 percent. The benefits of expanding wetlands from 27,000 acres to 125,000 acres and increasing waterbird populations by 40 percent is $2.5 billion. It is important to note the diminishing incremental benefits would apply to additional wetlands in excess of 125,000 acres. That is, the total benefits of increasing wetlands to 225,000 acres would not be $5 billion ($2.5 billion times two), but perhaps $3.75 billion. The benefits of restoring chinook populations to the San Joaquin River is worth $1.8 billion. It is also important to note that the total benefits for performing all three improvement programs is *not* the simple sum of these three benefit estimates. Research by Loomis et al. (unpublished) indicates there are statistically significant interaction effects between these programs. The aggregate benefits for performing all three improvement programs appears to be about half as much as the simple sum of the individual program benefits. This result is consistent with economic theory of benefit measurement (Hoehn and Randall 1989).

Table 2. State of California residents benefits from wildlife management in the San Joaquin Valley.

Program	Mean value per household	Total benefits (millions)
Wetland maintenance	$154	$1,515
Wetland improvement	$254	$2,501
Contamination maintenance	$188	$1,849
Contamination improvement	$313	$3,077
Salmon improvement	$183	$1,800

Some Approximate Benefit to Cost Comparisons

Of course, these benefits would need to be compared to the cost of water and wildlife management necessary to increase wetlands and fisheries as well as to reduce contamination. For example, to increase wetland acreage from the current 85,000 acres to 125,000 would require about 410,000 acre feet of water annually (Jones and Stokes Associates 1989:16). Gibbsons' (1986:38) survey of irrigation values of water in the San Joaquin Valley shows the $40 per acre foot associated with cotton and melons is about the highest value in the region. Updating this value to 1988, the annual cost of 410,000 acre feet would be $23 million. The annual conveyance costs, operation, maintenance, power and annualized construction cost (if any) associated with delivering about half this water volume to the eight refuges and wildlife management areas as well as the Grasslands Resources Conservation District has been estimated by the Bureau of Reclamation to be $1.53 million (U.S. Bureau of Reclamation 1987). Even if the costs for delivering the full 410,000 acre feet of water were twice this $1.53 million figure, the $2.5 billion in benefits of expanding wetlands to 125,000 acres substantially outweighs the water and conveyance costs of $26 million per year.

The amount of water required to provide the minimum 150 cfs releases needed from October through January for spawning and adult migration of chinook salmon would be 44,000 acre feet annually (Jones and Stokes Associates 1989:26). Adding to this the expected value of supplemental flows for outmigration during dry years brings the total to 61,500 acre feet. If these water releases could not be used downstream at that time of year and reduced the amount of water available to agriculture, the cost would be $3.5 million using the same agricultural water values from Gibbons as before. In addition, there may be some small loss in hydropower values as well since two of the irrigation canals have "run of the river" hydropower that generates power from irrigation releases. If water releases for fish in the river reduce irrigation releases in these canals, then there would be foregone hydropower values. This is likely to be quite small however. Given these relatively small costs, it appears that the benefits to society outweigh the opportunity costs of providing the flow to the San Joaquin River and salmon.

Conclusion

This research has demonstrated the acceptability of the voter referendum format as a useful mechanism to record society's willingness to pay for improving wetlands and wildlife in the San Joaquin Valley. This format had the lowest protest rate of any contingent valuation method approach reviewed. Only about 5 percent of the respondents rejected the simulated voter referendum as not being a credible or fair approach to solving environmental problems in the San Joaquin Valley.

The estimate of benefits per household was quite precise with the 90 percent confidence interval being within 10 percent of the mean willingness to pay. The best estimate of California's total willingness to pay to largely eliminate waterbird exposure to contamination is $3 billion. Increasing the amount of wetlands is worth $2.5 billion.

These values strongly suggest that Californians are concerned about the loss of wetlands and the exposure of wild birds to contamination. The benefits of correcting these threats to wildlife appear to substantially outweigh the cost of the control measures. Implicit in these comparisons is that the value of the first half million acre feet of water needed to produce wetlands and wildlife free of contamination is worth more than what that half million acre feet of water could produce in agricultural production. Given society's rising value for wildlife, far too little water has gone to wildlife and far too much to agriculture. Western water law should be flexible enough to recognize the changing value of water to society. Wholesale changes in water use are not needed. Rather, an incremental reallocation of a few percentage points of agriculture's use of nearly 90 percent of California's available water to wildlife would restore the balance in the San Joaquin Valley.

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Precipitation, Waterfowl Densities and Mycotoxins: Their Potential Effect on Avian Cholera Epizootics in the Nebraska Rainwater Basin Area

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Introduction

Avian cholera (*Pasteurella multocida*) is an infectious disease which commonly affects domestic and wild birds in many countries of the world. In North America, avian cholera has usually occurred more commonly in waterfowl wintering in western and southwestern geographical regions, but epizootics have occurred in all flyways, during both northward and southward migration, and on Canadian nesting grounds (Wobeser 1981, Brand 1984).

Waterfowl mortality due to avian cholera was first diagnosed in the rainwater basin area of southcentral Nebraska in 1975 (Zinkl et al. 1977). This area in Nebraska is now considered an enzootic area of avian cholera because waterfowl have sustained annual losses from this disease since 1975 (Ringelman et al. 1989, Windingstad et al. 1984, 1988). This area has also become increasingly more important as a northern winter-use site for waterfowl, primarily mallards (*Anas platyrhynchos*) (Jorde et al. 1983). However, the source of *P. multocida* in epizootics has not been established despite a great deal of research effort (Wilson 1979, Wobeser 1981, Mulcahy et al. 1988). Also, the means of avian cholera transmission or initiation among wild waterfowl is still unknown, but several probable causes of infection have been proposed and subsequently have had some investigation.

Prior to 1987, several studies were conducted in Nebraska on the extent of avian cholera epizootics among avian species, primarily waterfowl, (Zinkl et al. 1977, Hurt 1984, 1985, Windingstad et al. 1984, 1988). Other studies concentrated on the possible association of wetland water quality variables (Price and Brand 1984),

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wetland vegetation diversity, and adjacent "buffer zones" of upland grassland (Brown et al. 1983) to avian cholera outbreaks.

In his book, *Diseases of Waterfowl*, Wobeser (1981:217) presented three methods of disease investigation: (1) the investigation and description of natural events (e.g., avian epizootics) as they occur, (2) the retrospective analysis of records of past occurrences or (3) the prospective study of planned events either in the field or the laboratory. He further stated that the successful investigation of disease occurrences involves the use of medical, ecological and mathematical skills. Rosen (1969) also suggests that waterfowl species should be considered as distinct units in the study of epizootics, especially in an "ecological approach" because of the differential susceptibility to avian cholera among species.

We chose an "ecological approach" to investigate avian cholera epizootics in Nebraska because (1) our expertise was mainly with waterfowl, wetland, and terrestrial ecology, (2) records and people knowledgeable of past occurrences of avian cholera in the rainwater basin area were still available for reference or consultation, and (3) most earlier investigations did not use an "ecological approach."

In 1987, the South Dakota Cooperative Fish and Wildlife Research Unit began several ecological studies in Nebraska relative to waterfowl mortality stemming from avian cholera epizootics and their relation to several environmental factors of wetlands, adjacent uplands land use, weather and waterfowl numbers (Gordon 1989, Smith 1988, Smith and Higgins 1990, and Smith et al. 1989). The objective of the present study was to develop a better understanding of the relations among waterfowl densities, severity of avian cholera epizootics, snowfall, and precipitation in the rainwater basin area of Nebraska.

Study Area

The rainwater basin area is in southcentral Nebraska. Although wetland basins occur as a continuum across the area, it is administratively divided into eastern and western regions (Figure 1). At the turn of the century, approximately 4,000 natural

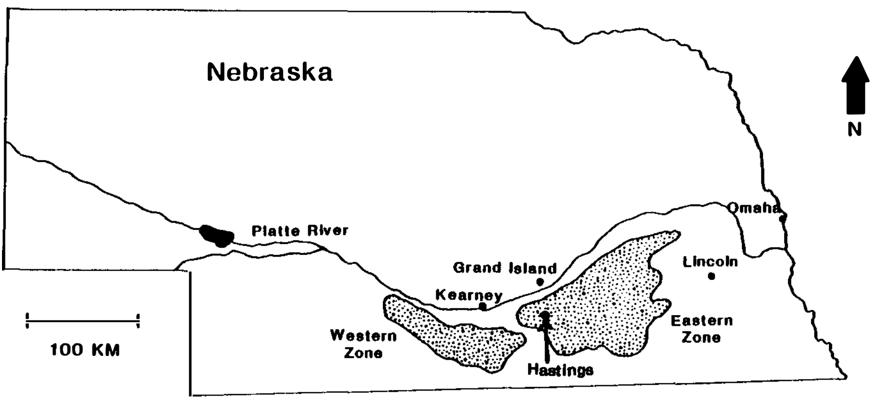

Figure 1. Location of the Nebraska Rainwater Basin Area.

wetland basins occupied about 94,000 acres (38,000 ha) of the area (Farrar 1982). Approximately 90 percent of these original wetland basins are gone or are nonfunctional, due primarily to drainage for agricultural purposes (McMurtrey et al. 1972, Farrar 1982, Smith and Higgins 1990). In an effort to preserve the remaining wetlands, about 15,494 acres (6,275 ha) of uplands and wetlands have been purchased for waterfowl production areas by the U.S. Fish and Wildlife Service and about 1,999 acres (809 ha) for game management areas by the State of Nebraska. In drier years, water for some wetlands is supplied by pumping directly from the Ogallala Aquifer.

Methods

Estimates of waterfowl losses to avian cholera and live waterfowl densities were provided by the Rainwater Basin Wetlands Management District and the Nebraska Game and Parks Commission personnel. Regression analyses at the $P \leq 0.05$ level were performed on the relation of the total estimated density of dead birds per acre to the high spring density of total live birds per acre on individual wetlands to determine if the severity of avian cholera epizootics was related to live waterfowl densities. Percent mortality of waterfowl per study wetland ($n = 47$) ranged from 0.1 to 14.8 percent and averaged 1.3 percent. Analyses were limited to 1988, 1985, 1984 and 1983, because these were years with complete data sets. Data analysis was done for the entire rainwater basin area, and then separately for the eastern and western regions. We used estimates of losses instead of the actual numbers of carcasses collected because collections were complete on some wetlands but incomplete on others, and estimates are considered to give a more accurate description of the severity of outbreaks. The live-waterfowl density values we used in the analyses were from the highest population estimate per wetland among a series of spring counts made annually by the U.S. Fish and Wildlife Service.

Weather information for Hastings, Nebraska, a centrally located reporting station (Figure 1), was obtained for the years 1975 through 1987 from the National Climatic Data Center, Asheville, North Carolina. Total snowfall accumulations (Table 1) and total precipitation (Table 2) were calculated at 10-, 30-, and 60-day time intervals prior to March 16 for each year. Precipitation was defined for our purposes to be rainfall + the snowfall's moisture equivalent. Accumulated snowfall was the sum of actual snow depth measurements per time period. Regression analyses (SAS 1985) were performed at the $P \leq 0.05$ level to determine if the severity of avian cholera epizootics (as measured by estimates of the total dead birds per wetland per year) was related to snowfall accumulation or precipitation per time interval.

Results

Waterfowl Densities

We found no significant relationship ($P = 0.26$) between the live and dead waterfowl densities per wetland for the entire rainwater basin area in 1983, however, there were positive relationships in 1984, 1985, and 1988 ($P < 0.05$) (Tables 3, 4, 5 and 6).

Table 1. Snowfall accumulation totals in centimeters per time interval prior to March 16 at Hastings, Nebraska.

Year	60-day	30-day	10-day	Total estimated dead
1975	36.1	31.0	27.9	22,500
1976	25.6	17.8	2.5	8,000
1977	12.9	5.1	0	8,750
1978	45.2	11.4	1.3	250
1979	30.5	20.3	0	875
1980	70.6	28.7	9.6	76,000
1981	19.8	9.6	0	7,922
1982	37.3	17.5	0	34,550
1983	24.6	0	0	15,200
1984	40.4	39.6	10.9	7,500
1985	19.0	0	0	3,000
1986	12.7	5.1	0	2,900
1987	0	0	0	2,800

In the eastern region, a significant relationship existed ($P = 0.02$) between the density of live and dead birds per wetland for 1983, but not for 1984, 1985, and 1988 ($P > 0.05$).

We found no significant relationship ($P = 0.22$) between the live and deadbird densities per wetland for the western region in 1983, but significant positive relationships existed for 1984 ($P = 0.04$) and 1985 ($P < 0.01$). We were only able to test three observations in 1983. In 1988 there were only two observations, not enough for analysis.

Snowfall and Precipitation

There were no significant relationships between the 10- and 30-day intervals of snow accumulations (Table 1) and the severity of avian cholera epizootics ($P = 0.25$

Table 2. Total precipitation in centimeters per time interval prior to March 16 at Hastings, Nebraska.

Year	60-day	30-day	10-day	Total estimated dead
1975	3.2	2.4	1.6	22,500
1976	2.8	2.1	0.8	8,000
1977	4.2	2.9	1.9	8,750
1978	3.2	0.7	0.1	250
1979	3.9	2.4	0	875
1980	4.8	1.6	0.8	76,000
1981	3.0	2.4	0	7,922
1982	3.3	1.1	0.1	34,550
1983	8.7	6.8	4.9	15,200
1984	5.2	5.1	0.3	7,500
1985	4.7	2.5	0	3,000
1986	3.8	2.6	1.7	2,900
1987	2.1	2.1	0.2	2,800

Table 3. Estimated total dead bird density per acre versus high live-bird density in the Rainwater Basin area of Nebraska for 1983.

Wetland	Dead-bird density/acre (ha)	High live-bird density/acre (ha)
Western region		
Funk	3.7 (9.1)	35.2 (87.0)
Prairie Dog	2.3 (5.6)	15.2 (37.5)
Cottonwood	4.3 (10.7)	67.2 (166.1)
Average	3.4 (8.5)	39.2 (96.9)
Eastern region		
Harvard	0.9 (2.3)	170.7 (421.8)
Massie	0.1 (0.2)	79.3 (195.9)
Smith	0.3 (0.7)	116.3 (287.5)
Mallard Haven	0.1 (0.2)	78.4 (193.7)
Average	0.4 (0.9)	111.2 (274.7)

and 0.15, respectively). However, there was a highly significant positive relationship between the 60-day total snow accumulation and number of waterfowl deaths attributed to avian cholera outbreaks ($P < 0.01$).

There were no significant relationships between precipitation totals (Table 2) for the 10-, 30- and 60-day intervals for each year prior to March 16 and the severity of avian cholera outbreaks ($P = 0.84$, 0.57 and 0.58, respectively).

Table 4. Estimated total dead bird density per acre versus high live-bird density in the Rainwater Basin area of Nebraska for 1984.

Wetland	Dead-bird density/acre (ha)	High live-bird density/acre (ha)
Western region		
Funk	1.2 (2.9)	212.8 (525.8)
Kennesaw	2.8 (6.9)	1,756.1 (4,339.3)
SE Sac	0.1 (0.2)	23.0 (56.8)
Prairie Dog	1.3 (3.2)	45.2 (111.6)
Lindau	2.9 (7.2)	197.0 (486.7)
Cottonwood	0.3 (0.8)	70.5 (174.3)
Quadhamer	0.4 (0.9)	14.6 (36.1)
Ritterbush	0.5 (1.3)	71.1 (175.7)
Gleason	0.2 (0.4)	12.5 (30.9)
Bluestem	2.6 (6.4)	310.0 (765.9)
Ayr	0.3 (0.7)	60.0 (148.2)
Average	1.1 (2.8)	252.0 (622.8)
Eastern region		
Harvard	0.6 (1.6)	175.6 (431.4)
Massie	0.1 (0.2)	97.1 (239.9)
Alberding	0.4 (1.0)	192.9 (476.6)
Hansen	0.1 (0.2)	58.4 (144.4)
Smith	0.4 (0.9)	113.4 (280.3)
Mallard Haven	0.3 (0.7)	62.7 (154.9)
Average	0.3 (0.8)	116.5 (287.9)

Table 5. Estimated total dead bird density per acre versus high live-bird density in the Rainwater Basin area of Nebraska for 1985.

Wetland	Dead-bird density/acre (ha)	High live-bird density/acre (ha)
Western region		
Funk	1.1 (2.7)	112.9 (278.9)
Kennesaw	15.0 (37.0)	774.5 (1,913.9)
SE Sac	0.6 (1.6)	20.4 (50.5)
Prairie Dog	0.5 (1.3)	52.5 (129.7)
Cottonwood	0.2 (0.5)	6.6 (16.3)
Lindau	1.0 (2.5)	73.1 (180.7)
Average	3.1 (7.6)	173.3 (428.3)
Eastern region		
Pintail	0.3 (0.7)	184.7 (456.3)
Kirkpatric	0.7 (1.8)	85.6 (211.6)
Harvard	0.5 (1.3)	112.5 (278.1)
Massie	0.2 (0.6)	110.8 (273.9)
Mallard Haven	0.1 (0.3)	114.0 (281.8)
McMurtrey	<0.1 (0.3)	14.3 (35.3)
Green Acres	0.3 (0.7)	61.2 (151.3)
Smith	0.1 (0.3)	156.3 (386.3)
Average	0.3 (0.7)	104.9 (259.3)

Discussion

Waterfowl Densities

Friend (1981:99) stated that, "Transmission of infectious disease is facilitated by the concentration of waterfowl at site-specific locations." He further stated that inclement weather can serve to crowd birds together, reduce activity patterns, and

Table 6. Estimated total dead bird density per acre versus high live-bird density in the Rainwater Basin area of Nebraska for 1988.

Wetland	Dead-bird density/acre (ha)	High live-bird density/acre (ha)
Western region		
Funk	4.2 (10.4)	295.5 (730.1)
Johnson	4.5 (11.1)	486.5 (1,202.2)
Average	4.3 (10.7)	391.0 (966.1)
Eastern region		
Massie	0.7 (1.8)	167.7 (414.5)
Harvard	1.7 (4.1)	130.0 (321.1)
Mallard Haven	0.4 (1.1)	167.5 (413.9)
County Line	0.4 (1.1)	111.3 (275.1)
Eckhardt	0.2 (0.6)	223.9 (553.3)
Smith	3.0 (7.3)	148.2 (366.3)
Hansen	0.5 (1.2)	75.2 (185.8)
Average	1.0 (2.5)	146.3 (361.4)

may provide a ''stress'' that precipitates eruption and transmission of infectious diseases such as avian cholera. For many years, concentration or overcrowding of waterfowl has been suggested as a factor contributing to avian cholera epizootics (Petrides and Bryant 1951, Vaught et al. 1967, Rosen 1969, Klukas and Locke 1970, Zinkl et al. 1977, Smith and Higgins 1990). Yet, others have presented evidence that suggests that the effects of overcrowding on avian cholera epizootics may not be too important (Rosen 1969, Montogomery et al. 1979, Gordon 1989).

Petrides and Bryant (1951) stated that outbreaks have occurred in wintering waterfowl on relatively small and shallow ponds and that it seemed likely that individual birds serve as carriers and are centers of infection under conditions of high population densities and low water levels. Our data support this concept for three of four years tested for the entire rainwater basin area, but not when the eastern and western regions were treated as separate entities. In some years, a positive relationship existed between the density of dead and live waterfowl in the west, but not in the eastern region for the same year.

Our ability to evaluate the issue of overcrowding in greater depth was limited by definition. Currently, there is no definition of what constitutes overcrowding or at what threshold of waterfowl density does overcrowding begin on a wetland. Definition is also confounded by the fact that waterfowl do not usually occupy 100 percent of, or are not evenly distributed over, a basin's area (Gordon 1989). Furthermore, total waterfowl numbers or survey estimates constantly change in time and space, especially on certain specific sites within major staging areas during migration periods. For example, and overnight freeze can cause waterfowl already present on an area to concentrate suddenly onto smaller areas of available open water, which in turn results in a sudden change in bird numbers per unit area in both time and space. In contrast, a more subtle long-term cause of overcrowding can occur because of drought (Rosen 1972) or wetland losses resulting from several years of drainage effort on the same area (Smith and Higgins 1990). Also, as winter progresses into spring, avian cholera epizootics usually lessen or dissipate totally as migration continues and birds disperse over a larger region free of snow and ice (Rosen and Bischoff 1949, Rosen 1972, Wobeser et al. 1979). Spring weather patterns in North and South Dakota may also significantly affect Nebraska epizootics by preventing or allowing birds to dissipate on the northerly migration. Because of these complicating factors, we submit that, while high population densities or crowding may be contributing factors to the severity of avian cholera epizootics, we do not think they are the sole origin or cause of disease outbreaks. Obviously, there exists a need for better definition of what criteria or what population density threshold constitutes overcrowding among waterfowl concentrations.

Precipitation Effects

Above usual amounts of precipitation, either rainfall or snowmelt, can increase the number and size of wetland areas enough to aid waterfowl dispersal, thus lessening overcrowding (Rosen 1969). Too much precipitation also increases dilution of soluble ions that may influence the survival of *P. multocida* organisms (Price and Brand 1984, Windingstad et al. 1984, Bredy and Botzler 1989). In contrast to water abundance, Petrides and Bryant (1951), Rosen (1972), and Zinkl et al. (1977) have pointed out some probable effects of too little precipitation or water in relation to avian cholera epizootics.

In our study, the snow accumulation values of the 60-day interval prior to March 16 were the most significantly related to waterfowl die-off estimates and the snowfall precipitation values tested in our analysis. The 60-day snow accumulation (70.6 cm) for 1980 was the highest among the 12 years we tested and also the year of the most severe avian cholera epizootic. However, when we conducted a regression without the 1980 data, the relationship between 60-day snow accumulations and the numbers of dead birds was no longer significant ($P = 0.29$). Data from 1978 and 1979 confuse this issue further, because these two years had extremely low waterfowl die-offs but above average snowfall accumulations. In addition to large amounts of snow, approximately 25,000 mallards overwintered in the rainwater basin area during 1980, respectively (Jorde et al. 1983). If any of those birds were cholera carriers, they may have been a contributing factor to the higher mortality in 1980. In contrast, approximately 5,000 mallards overwintered in 1979, a year of low snowfall and low bird mortality.

Currently, there appears to be no strong evidence that *P. multocida* could survive over winter in soil or water (Backstrand and Botzler 1986) even though some ions in wetlands may enhance its survival (Price and Brand 1984). Bredy and Botzler (1989) have also demonstrated that survival of *P. multocida* is less with colder temperatures (2°C versus 18°C) such as would occur with snow conditions. In view of the fact that some epizootics were associated with cold temperatures and snow storms (Zinkl et al. 1977, Windingstad et al. 1988) and others were not (Brand 1984), it appears evident that orgination of an avian cholera epizootic is most probable from a warm-bodied host. If from a warm-bodied host, the bacterium might originate by transmission from one area to another via unhealthy carrier birds, initiate latently from individuals infected during a previous epizootic, initiate from a latent infection from an endogenous warm-bodied carrier species already present on the site, such as muskrats (*Ondatra zibethicus*), mink (*Mustela vison*) or raccoons (*Procyon lotor*), as well as a large variety of other mammals and birds (Bond et al. 1972, Brogden and Rhoades 1983, Quan et al. 1986, Snipes et al. 1988), or initiate after some predisposing agent or "stressor" already present on an area exacerbates a latent "low-grade" infection via immunosuppression effects.

A Cause-and-effect Hypothesis

Biologically and ecologically speaking, how could precipitation and snowfall amounts relate to avian cholera epizootics in Nebraska other than through physiological stress, bird concentration, or accessibility to foods, primarily waste grains? And why do waterfowl die-offs occur on one wetland and not the next one? Because the answers to these questions are apparently not related to characteristics of the wetland proper (Zinkl et al. 1977, Brand 1984, Price and Brand 1984, Windingstad et al. 1988, Backstrand and Botzler 1989, Bredy and Botzler 1989, Gordon 1989) or to feedlots or grasslands adjacent to wetlands (Brown et al. 1983, Windingstad et al. 1984, Smith et al. 1989), we submit that there is a strong possibility of an environmental catalyst to epizootics that may be unrelated to wetlands. Furthermore, we suspect the catalyst might be related to the quality of waste grains in fields where waterfowl feed.

We propose the hypothesis (Figure 2) that a connection exists among fields with moldy grain, feeding behavior of waterfowl, and avian cholera epizootics during fall, winter or early spring. We deductively based our hypothesis on the following

Conditions for Lower Incidence of Avian Cholera Epizootics

Normal to Dry Summer and Fall
Reduced Winter Snow Amounts and Duration

Waterfowl Arrive: Normal Staging Period & northerly migration
▼
Waste grain more available over entire area
▼
Less stress on birds
▼
Less production of fungi, moldy grain & mycotoxins
▼
Less chance of exposure to predisposing effects from mycotoxins
▼
Less mortality due to avian cholera

Conditions for Higher Incidence of Avian Cholera Epizootics

Wet Summer and/or Fall
Greater Winter Snow Amounts & Duration (colder) in Nebraska & Farther North

Waterfowl arrive: waterfowl more concentrated during staging period and northerly migration delayed or halted
▼
Waste grain less available over entire area
▼
More stress on birds
▼
More production of fungi, moldy grain, and myctoxins
▼
Greater chance of exposure to predisposing effects from mycotoxins
▼
Greater mortality due to avian cholera

Figure 2. A hypothetical model of a cause-and-effect relationship of weather, waste grain and mycotoxins to avian cholera epizootics in Nebraska.

set of questions and answers. Question one: how, other than being concentrated on individual wetlands with overwhelming numbers of bacteria per wetland, could a flock of waterfowl be mutually affected by stress or some predisposing agent to avian cholera? Answer: one key to understanding the proposed relation is flock behavior. Waterfowl traditionally travel in separate flocks between wetland resting sites and cropland feeding sites with little mixing among flocks, except when hazing occurs. This kind of flock behavior would expose a discrete group of birds. Thus, any contracted disease or predisposing agent might remain within specific flocks. Also, the same wetland, or a portion thereof, may be used by a flock for several consecutive days, whereas feeding sites may change daily. This kind of behavior may help to explain why waterfowl are found dead on some wetlands and not others. Robinson et al. (1982:313) lend support to this concept as follows: "The large number of birds found dead at Lake Proctor and Lake Leon (the only two resting lakes available) could be attributed to the fact that the ducks picked up the toxic peanuts in the fields and then flew to the lakes to rest. Eventually they became too weak to leave the lakes and the sick and dead birds were concentrated on these lake areas."

Question two: what predisposing agents to avian cholera potentially exist in field situations where waterfowl feed (mainly a corn, soybean, sorghum cropping area)? Answer: chemical fertilizers, pesticides and toxins on waste grains are three possible predisposiong agents in the rainwater basin area of Nebraska. But when you consider that most annual epizootics occur before most farming operations occure (Feb.–April), it seems reasonable to reject chemical fertilizers and pesticides as causal predisposing agents. Further, support for their rejection is relative to snow depth, a condition which would lower the availability of most chemicals and also make them more difficult, but not impossible, to ingest. Thus, toxic waste grains appear to be the most probable predisposing agent during autumn through early spring.

Question three: what toxins on grain could act as a predisposing agent to avian cholera outbreaks? Answer: mycotoxins on moldy waste grains. Mycotoxins are a group of toxic metabolites produced by toxinogenic molds, often on feed grains including corn and most cereal grains (Joffe 1962). While several mycotoxins occur frequently and over wide geographic areas, mycotoxin formation and occurrence on grains is often limited geographically and is closely associated with environmental factors such as ambient temperature, relative humidity, drought stress, insect infestation, and mechanical damage during harvest (Osweiler et al. 1985). Mycotoxins can persist on waste grains under a wide range of temperature ($\pm$ 0°–47°C) and moisture conditions. Also, there is speculation (Cole et al. 1988) that mycotoxin production may occur or be enhanced by rehydration of waste grains by snow or rain in conjunction with freezing and thawing temperatures. Evidence to support this deduction includes a diagnosis of fusariomycotoxicosis in winter die-offs of sandhill cranes (*Grus canadensis*) in Texas which was associated with trichothecene mycotoxins produced by *Fusarium* sp. on moldy peanuts during cold, wet weather (Windingstad et al. 1989, Roffe et al. 1989). Two other cases included trichothecene T-2 poisoning of domestic geese in British Columbia from the ingestion of contaminated barley that had been left over winter in the field (Greenway and Puls 1976, Puls and Greenway 1976), and aflatoxin B_1 poisoning of mallards, sandhill cranes, and snow geese (*Anser caerulescens*) in Texas (Robinson et al. 1982, Windingstad 1988).

Also, certain of the trichothecenes, notably T-2 toxin, may be particularly important to waterfowl because production of this toxin is favored by long-duration, low-temperature incubation (Greenway and Puls 1976, Wobeser 1981). Furthermore, mold growth and mycotoxins may sometimes make waste grains unpalatable (Hayes and Wobeser 1983) or of low choice; however, factors such as extreme cold or snow depth may force birds to feed in contaminated fields or feedlots that they might otherwise avoid (Locke 1987). For example, Windingstad et al. (1988) and Jorde et al. (1983) reported that wintering mallards fed heavily in grazed corn stubble and in feedlots in Nebraska. Jorde et al. (1983) also demonstrated that mallard flock competition for waste grain in rainwater basin area corn fields was markedly higher during the cold winter of 1979–80 when heavy snow cover was present. They also reported that cattle trampling of snow facilitated mallard feeding activities by exposing corn ears and kernels. This may account for the observation that waterfowl feed in these fields regardless of the presence of snow. Snowfall accumulations may merely dictate the proximity of waterfowl feeding in relation to livestock as a means to enhance their accessibility to waste grain in order to meet thermoregulatory demands. Thus, in years of high snowfall, the prolonged effect of mallards feeding in close proximity to cattle may increase their direct exposure to *P. multocida*, if cattle can be considered reservoirs for the bacterium; however, there is little evidence in support of this idea (Heddleston and Watko 1963). A more probable relation is the increased exposure of waterfowl to toxic grains. Because many waterfowl feed extensively on waste cereal grain left in fields during fall, winter and spring, this would also appear to enhance the possibility for waterfowl exposure to mycotoxins. Waterfowl may also feed on grain used as waterfowl bait (Robinson et al. 1982) or on grain fields that are periodically flooded (Hazlewood et al. 1978), which may help explain how some non-field feeding species of diving ducks and rails are exposed to toxic grains.

And finally, prolonged ingestion of palatable grains contaminated with low levels of mycotoxin may result in lethal mycotoxicosis more often than previously shown (Greenway and Puls 1976). Bryden (1986), Christensen et al. (1977) and Pier et al. (1980) have also pointed out that a most insidious effect of low level mycotoxin ingestion is impairment of resistance to disease. This effect is often difficult to recognize because signs of the disease are often associated with the infection rather than the toxin that predisposed the animal to the infection.

Conclusions and Recommendations

Despite some weaknesses with the dead-bird pickup data, we found some significant relationships of snowfall amounts and live-bird densities to dead-bird densities stemming from avian cholera epizootics in the rainwater basin area of Nebraska. These findings and those of Locke (1987) suggest that initiation of an epizootic could be due just as much to external factors, such as weather and feeding behavior, as they are to the wetlands where birds die and are picked up. Although any of a multitude of factors or their combination may be responsible for avian cholera epizootics, we are proposing the concept that a predisposing agent, most likely mycotoxins on moldy waste grains, may be the most probable cause of epizootic origins among the several possibilities. We make this proposal on the basis that moist conditions during pre-harvest plus moist fall/winter conditions (snow accumulations) create environmental conditions conducive to the production or retention of molds, fungi, and bacteria and likewise the production and durancy of their by-products (e.g., mycotoxins) which, when ingested predispose waterfowl to avian cholera or act as an immune suppressant. In addition to the possible relation of moldy grain to avian cholera outbreaks, there also is evidence of waterfowl mortality stemming from aspergillosis (*Aspergillus fumigatus*) after birds feed on moldy grain (McDiarmid 1955).

For the future, we recommend additional research in various geographic regions on the cause and effect relationship among waterfowl, weather, mycotoxins and agronomic field practices. This could be best done with a multi-discipline approach involving field and laboratory projects and a more intense retrospective analysis of records of past occurrences and events which would help our understanding of weather effects on toxigenic molds in waste grains and their relation to avian cholera epizootics.

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Special Session 7. *Goose Management in the '90s*

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Perspectives on Goose Management in North America: Challenges and Opportunities for the '90s

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This session deals with the monitoring and management of goose populations in North America, with a focus on directions in management for the next decade. It is occasioned by some dramatic changes in the status of waterfowl, and thus a need to shift our focus on management of these resources. It is widely recognized that duck populations experienced large declines during the decade just completed. Over this same period, however, most populations of geese fared well. A review of the status of goose populations identified in the North American Waterfowl Management Plan indicates stable or increasing levels for most populations.

Notwithstanding generally favorable trends, there are concerns about the status of certain populations of geese, and about our overall capabilities to monitor and manage geese. Several populations in the Pacific Flyway have experienced long-term declines and now are at low levels. Recent declines have been recorded in stocks of Canada geese in the Atlantic Flyway, and the status of white fronts continues to be a matter of great concern. Distributions of geese have changed as well, and nonmigratory "resident" goose populations have grown dramatically in some areas. Monitoring programs necessary for managing geese under these conditions are lacking for many populations, and there is only limited information on recruitment and the population impacts of disease and other factors. These problems constitute a clear challenge to develop monitoring programs and management tools in order to meet harvest and other management objectives.

Several developments offer hope that this challenge can be met. Advances in areas such as remote sensing, survey techniques, and the use of color marking bring improved capabilities for monitoring populations and determining their distributions. Equally important, there are newly developed, or currently developing, structures for cooperative management that provide exciting new opportunities for goose management. We mention four factors that are leading us into a new era of goose management in the 1990s.

First are the changed status and distribution of many populations of North American geese. While North American populations of ducks declined during the 1980s, largely in response to combined impacts of long-term drought, intensive agricultural practices and land development, many North American goose populations increased. At the same time that scaup, pintail, blue-winged teal, mallard and American wigeon were reaching record or near-record lows, many populations of geese, most notably Canada and snow geese, were at record or near-record highs. Long-term shifts in the distribution of geese from traditional southern wintering grounds to areas farther north also have occurred, and east-west redistributions have been documented. Buildups of large stocks of geese, often consisting of resident as well as migratory geese, have resulted in habitat destruction, crop depredations, and nuisance problems in some areas. The changing status of geese has led to a greater interest in their sport harvest, resulting in increased goose harvests coincident with declines in the harvest of ducks. When combined with concerns about the depressed status of certain regional stocks, these factors have led to an increasingly complicated management environment and to intricate, highly refined harvest regulations. Thus the biological situation that managers face in the 1990s is very different, and in many ways considerably more complex, than that experienced 20 years ago. These differences serve as strong motivations for a heightened focus on goose management issues.

Second, the North American Waterfowl Management Plan is moving "full steam ahead." The North American Waterfowl Management Plan was signed in 1986 by Canada and the U.S. in recognition of serious problems with North American waterfowl, and in recognition of the need for cooperative efforts among public and private partners to solve them. Several joint ventures in the U.S. and Canada now are underway, and the recently enacted North American Wetlands Conservation Act will provide Federal assistance in implementing the Plan. Mandated in the Plan was an Arctic Goose Joint Venture, which was to address information needs concerning status of populations of Arctic nesting geese. At this time both steering and technical committees have been named for the Arctic Goose Joint Venture, and in fact several members of these committees are contributors to these proceedings. An Arctic Goose Joint Venture Prospectus is nearing completion, and a writing committee has been formed to produce a strategic work plan by September of 1990. The Arctic Goose Joint Venture will play a key role in the 1990s in coordinating efforts to monitor geese and in identifying additional information needs for management. By combining resources and working together through the Joint Venture, the intent is for us to accomplish together what we otherwise could not accomplish alone.

A third factor moving us into the new decade is a recognition by the flyway councils, the U.S. Fish and Wildlife Service and others of the need for a redefined and expanded role for the Fish and Wildlife Service in goose management. In recent years the flyway councils have actively encouraged the Service to expand its role as a fully cooperative partner in the management of geese. To meet broadly recognized management needs, the Service is now completing a North American goose management strategy that charts a long-term course for itself in monitoring and management of geese. The strategy will highlight current management programs, identify key management and information needs and outline a program to meet these needs. Among other things, it will incorporate a shift in the Service focus more toward the breeding grounds. It also will mandate a revision of the Service Waterfowl Harvest Survey to focus on harvest of geese as well as the harvest of ducks. It will advocate the use of color-marking in the context of studies designed for specific, well-defined problems. And it will set a schedule for development of breeding ground surveys and banding programs. In essense, the strategy will establish the Service perspective on goose management and lay out a new course of action over the next five years and beyond. The resources necessary to implement this strategy must be incorporated into the annual budgeting process for the Service, and thus will be influenced, as always, by strong support from conservation groups.

Finally, a fourth factor defining goose management in the 1990s is the advent of new technologies in monitoring and assessment of geese. Many of these advances, especially in the areas of remote sensing, banding analysis and color marking, are just now coming "on line," and hold great promise in improving our ability to manage geese. The session participants discuss some of these exciting developments, which will be extremely useful in addressing a large number of difficult problems facing managers, ranging from the determination of population size and distribution, to the measurement of productivity, to identification of regional patterns of migratory movements. With new information of this kind, managers will be able to regulate harvest more effectively, while providing protection to those populations that require it.

This session provides perspectives on where we are now in the business of managing geese, how we came to be at this juncture and where we hope to go during the decade of the 1990s. The leadoff presentation gives a historical perspective on goose management in North America. This is followed by presentations on goose management in each of the four flyways, and a perspective on management issues in Canada. Papers also are included on current monitoring programs and prospects for the future of goose monitoring, with separate presentations on surveys and on banding and color marking. Finally, the session co-chairman summarizes the session and provides some "take-home" messages. We seek in this session to answer the following three questions: (1) What are the problems facing managers of North American geese today? (2) What actions are ongoing and what actions can be taken for their solution? (3) What are proper roles for the partners who together have responsibility for management of geese?

History of Goose Management in North America

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Introduction

The presence and general distribution of the various groups of geese as we know them today was well documented by the early explorers of North America. As they compiled information on wildlife and their habitats, it became evident that the larger forms of birds and animals were sought after by native people. This was also true for waterfowl, with geese and swans being the prime targets (Delacour 1954). As adventurers with ornithological interests entered the scene, recorded observations became more specific and the distinction between various types of waterfowl, especially geese, became more definitive. J. R. Forster (1772), a naturalist who sailed with Captain Cook during some of his early Arctic explorations, wrote one of the earlier accounts about the vast flocks of white geese and how the Indians of James Bay systematically hunted them for food during the fall migration. Over time, naturalists and ornithologists such as A. C. Bent and W. W. Cooke began to identify the species and races of geese present and described what they learned based on field collections and observed distribution of geese, or hypothesized about their seasonal distribution. But much remained unknown about the breeding grounds of most geese until the early 1990s because of the inaccessibility of Arctic and subarctic breeding areas (Phillips and Lincoln 1930).

As the settlers moved westward across the U.S., waterfowl were an important seasonal food item. Geese are frequently mentioned in their journals, especially the large Canada goose that was then breeding in portions of northcentral and northwestern U.S. (Hanson 1965). Most local nesting geese, and certainly nesting trumpeter swans, were extirpated soon after settlement. The first real management efforts related to geese may have been by the early settlers in the prairies, who removed eggs from wild Canada goose nests and hatched them under chickens to develop their own captive goose flocks. Some were also used as live decoys for goose hunting, and these flocks fortuitously proved to be the stock that maintained the giant Canada goose gene pool in the Midwest (Dill and Lee 1970). Jack Miner established the Miner Bird Sanctuary near Kingsville, Ontario, during the period 1904–1910 primarily to attract migrant Canada geese (Miner 1923). During the period 1880–1910 there was increased concern over the impact of market hunting on waterfowl and regulatory measures began to be imposed. This culminated with the signing of the Migratory Bird Treaty Act between the U.S. and Canada in 1916, followed by the development of federal regulatory procedures for the protection and management of migratory birds in both countries. Meanwhile, the Bureau of Biological Survey, established in 1896, the predecessor of the U.S. Fish and Wildlife Service, had begun to collect basic biological information on waterfowl and their habitats, including geese (Hawkins 1984).

As interest in sport hunting increased and state provincial wildlife management organizations were established, emphasis on waterfowl and their habitats increased. Coordination of regulations between states began. For example, Wisconsin closed the season on wood ducks in 1860. Most states had established hunting seasons for ducks by 1899, but geese were not afforded comparable protection until 1913 and later.

Goose management efforts became more intensive during the 1930s through the 1940s. Certain national wildlife refuges and state wildlife areas were established and managed specifically for geese, primarily for Canada geese and snow geese. To name a few, the Horseshoe Lake Refuge established in Illinois in 1927 became a major Canada goose concentration area by the early 1940s. Gaddy's pond, established in 1934 in North Carolina, quickly became another major concentration area in the East. Passage of the Federal Aid in Wildlife Restoration Act in 1937 (P-R Act) provided new incentives to acquire, develop and manage state wildlife areas for waterfowl. Many new areas became famous, and some infamous, in the goose hunters' world. Places like Sand Lake Refuge, South Dakota; Swan Lake Refuge, Missouri; Union County Refuge, Illinois; Horicon Refuge, Wisconsin; Tule-Klamath Refuge, Oregon-California; Sacramento Refuge, California; Devils Lake, North Dakota; Katie-Lizzie Prairie areas in east Texas, Lacassine and Sabine refuges and adjacent areas in Louisiana, and Remington Farms, Maryland, became well known and gained varying degrees of notoriety. Goose hunters and observers were also attracted to areas in Canada such as southern James Bay; Kindersley and Quill Lakes areas in Saskatchewan; and more recently, the Oak-Hammock area in Manitoba, and Cape Tourmente, Quebec.

The pristine marshes of the migration and wintering grounds, where geese fed on succulent vegetation, seeds and tubers, gave way to fields of rice, wheat, corn and soybeans. Other industrial development changed the character of river systems and coastal marshes, but geese adapted quite well to some agricultural changes. During the past 40 years, wintering snow, Canada and white-fronted geese, along with mallards and pintails, have moved out of the coastal marshes of Louisiana and Texas and the bottomlands of Arkansas and Mississippi to nearby rice fields (Chabreck et al. 1989). Today, in many migration and wintering areas, geese seek out waste cereal grains and corn as well as newly sprouted seedlings.

Evolution of Management Concepts

Regulations

Regulations have been first and foremost among the tools for managing geese. During 1919–1929 goose limits were a generous eight per day (any species) with no possession limits. An additional eight brant per day could be taken in Pacific Coast states. Season length was 107 days. In 1930 goose limits were reduced to four per day, with a possession limit of twice the daily bag established for the first time. Seasons were closed nationwide on Ross geese (1931–1962), cackling geese (1931–

32) and on all white geese in the Atlantic Coastal States (1931–1969). The 30-day seasons during 1934–1937 applied to geese as well as ducks. In sharp contrast to the nationwide, nearly uniform regulation during 1919–1946, the 1989 season on "white" geese ranged from a daily limit of five and 107 days in the Central Flyway to three and 65 days in portions of the Pacific Flyway.

Intensive Management

The establishment of the flyway system, the flyway councils and technical committees during 1947–1952 provided a new framework for cooperative management of waterfowl between the federal governments, states, provinces and private organizations. The subsequent preparation of flyway management plans during the 1950s also fostered the development of the species management concept. Historically, goose management efforts have been directed at population restoration, redistribution and appropriate harvest. Some of the principal early management philosophies, objectives and practices included:

- Provision of adequate protection and food for the increasing numbers of geese using federal and state managed areas.
- Determination of the optimum location and distance between these management areas to facilitate an orderly migration pattern.
- Determination of different ecological requirements for the various populations of Canada geese, snow geese, white-fronted geese and brant.
- Recognized need to develop better methods for identifying the various populations (races) of Canada geese.
- Improvement of banding and survey techniques to increase knowledge of seasonal distribution and population dynamics.
- Providing optimum hunting opportunity without jeopardizing desired population size.
- Development of annual population harvest quotas by state or area where applicable and necessary, particularly for certain populations of Canada geese.

Obviously, the most intensive goose management programs have been developed for Canada geese. As the identity of specific "populations" or "flocks" of Canada geese and their seasonal distribution and population dynamics became better understood, more intensive management practices were attempted. Over time, specific management plans were developed for given populations or flocks. There are about 30 such plans in effect today.

Cooperative management was coordinated through the respective flyway councils. New restrictive regulations were imposed to control kill, provide hunting opportunity and to improve the quality of hunting. Such measures included annual harvest quotas, closed seasons and zones, delayed opening dates, special shooting hours, licensing of private hunting clubs, blind spacing and mandatory reporting of daily kill. Goose management began to get complicated. Nelson (1962) summarized the results of 15 years of various attempts to manage intensively the principal Canada goose populations in central and eastern United States. Goose management has continued to get more complex since then.

The classic case history is the Mississippi Valley population of Canada geese. In the late 1940s, Canada goose management in the Mississippi Flyway centered around the Horseshoe Lake flock in Illinois. Intensive research conducted on this population and related management activities was reported by Hanson and Smith (1950) and it has been the subject of numerous other reports since. Waterfowl managers who have been personally involved in many of the deliberations the past 40 years will likely agree that no single population of waterfowl in North America has been subjected to such intensive scrutiny and debate.

Population Assessment

During recent years waterfowl managers have attempted to work with about 30 identifiable populations of geese. The North American Waterfowl Management Plan (U.S. Department of the Interior and Environment Canada 1986) lists 27 separate populations, excluding the giant Canada goose, Vancouver Canada goose and Emperor goose that have a more restricted distribution. Only a limited number of these populations are surveyed regularly, some not at all.

The coordinated mid-winter waterfowl survey, initiated in 1936, still provides the best basic information for managing most goose populations in North America. Since there presently are only limited experimental surveys of the remote Arctic breeding grounds, estimates made of all major wintering concentrations of geese at a specified time provide indices to population trends.

Nation-wide harvest surveys for waterfowl were initiated in 1952. This mail survey of hunters, now conducted annually in the U.S. and Canada, was expanded to include geese in 1962. Harvest estimates of the annual goose kill are calculated for four groups: Canada geese, brant, snow geese and white-fronted geese (Smith et al. 1989).

Banding, color-marking and telemetry techniques have provided increasing knowledge, but not adequate understanding of seasonal patterns of distribution, harvest, survival, recruitment and behavior to meet intensive management requirements. The need for more precise information in management of goose populations or races is beginning to rival that sought in the management of anadromous fish stocks. There has been much confusion over the years in the definition and use of the terms population, flock and race (Hansen and Nelson 1964).

Other speakers will provide more detailed information on population trends, annual harvest and related management problems.

New Dimensions

In general, the management of wild goose populations over the past 40 years has been notably successful, although it has been based to a large degree on empirical experience. But, we have learned much from our collective successes and failures. Henceforth, however, research as well as management must be based insofar as possible on the taxonomic identity of goose populations and their interrelationships; especially Canada geese. This is a large order because of the results of research conducted over the past 27 years by the Illinois Natural History Survey. It is now recognized that, unless we establish the racial identity of geographic populations in the northern breeding grounds and on major staging and wintering areas, the results from many current and future management investigations will have limited relevancy. Long-term studies now being completed and soon to be published on the taxonomy and racial distribution of white-cheeked geese by Dr. Harold C. Hanson of the Illinois Natural History Survey will provide a new dimension for future research and management. He is suggesting that there are three main species and over 130 races of white-cheeked geese. Dr. Hanson has clearly established the morphological differences between designated races. The geographic origins of many of the races of white-cheeked geese are known only in respect to the 10 major migration routes or flyway systems they relate to (H. C. Hanson, personal correspondence: 1990). Clearly, past management and research have been but prologue to a fresh and challenging future. We will have to be prepared to reassess many of our past management actions and be willing to start anew as racial identity and distribution dictate. I have seen the Illinois Natural History Survey collection of white-cheeked geese. The diversity of the races in respect to size, proportions and color is truly mind boggling.

Lessons From the Past

It is with appreciation of this biodiversity in white-cheeked geese that we preface our remarks on what we have learned from our collective experiences in management of goose populations. We believe the following are the most significant.

- Harvest management strategies for some known racial populations of Canada geese have worked reasonably well in recent years but do not always permit the precise degree of control or results desired because of their mixing with other races of unknown identity during migration and on wintering areas. The result is that band recoveries have had limited usefulness in appraising populations. Color-marking and systematic observations of marked birds have proved to be more useful.
- We have not been successful in directly influencing major changes in distribution of certain populations of geese through desired management actions—nor should we perhaps try further. The term "shortstopping," often applied to increasing numbers of geese wintering farther north, seems inappropriate because it implies a planned management action. Perhaps in the future, as goose numbers increase, there will be an overflow back into the more southerly areas that now have few or no geese.
- Special cooperative management efforts and restrictive hunting regulations, including season closure, have yielded positive results for some species or races such as the Aleutian Canada goose, cackling Canada goose, emperor goose, some populations of white-fronted geese and brant. The status of Aleutian Canada geese and cackling geese and current management practices should be analyzed critically in view of Hanson's treatment of these races. There is renewed concern over maintaining the integrity of island populations.
- Most goose populations continue to be dynamic and respond to subtle changes in habitat quality, hunting pressure, changes in availability of water and protected resting areas, and changing agricultural practices.
- Remote northern breeding areas, some yet unknown, are subject to change and must be monitored more closely to detect variations in weather patterns, food resources, breeding population size and annual recruitment. Close scrutiny must be maintained over oil and gas development and other human disturbances.
- The restoration of the giant Canada goose and related urban goose programs have been successful to the point that many local populations are becoming overly abundant. This will require new, innovative management techniques to control further expansion, yet maximize related recreational opportunities, including hunting, in these urban situations (Nelson and Oetting 1982).
- Commercialization of goose hunting in areas where geese concentrate during

fall and winter has resulted in significant economic values; many positive, some negative.

Current Issues

Our analysis of current goose management programs identified a number of significant issues that must be addressed to improve future management capabilities. The following are highlighted:

- We do not know the geographic origins of many populations of geese and the degree to which they mix on migration and wintering areas.
- Databases are inadequate for most racial-geographic populations of geese we are attempting to manage intensively. This emphasizes the need for better information on breeding population size, distribution, annual recruitment, harvest and survival.
- We need to develop survey and banding programs for geese similar to those conducted for ducks. The challenges are infinitely more complex, particularly because of the racial diversity and distribution of the white-cheeked geese now realized.
- We must improve our understanding of conditions of northern breeding grounds and annual productivity to aid in the development of better long-term management strategies. The Arctic Goose Joint Venture being implemented under the North American Waterfowl Management Plan is a major step in that direction.
- We need to better understand the carrying capacity of Arctic breeding area. For example, can we expect snow goose breeding populations to continue to expand their range or will over-utilization of food resources occur in traditional breeding areas as Graham Cooch speculated during the early 1960s (Cooch 1964).
- We need to reassess long-term habitat needs, population objectives and harvest strategies in relation to the objectives of the North American Waterfowl Management Plan.
- We should begin to assess potential long-term changes in climatic influences on agricultural programs and land management practices in the future that may further influence seasonal habitats used by geese.
- It will be important to predict potential population declines and major crashes well in advance of occurrence. This will require much improved knowledge of population dynamics.
- We need to devote more research effort to key disease problems, especially avian cholera.
- We need to launch a major effort at the field biologist level to better understand and identify the many races of Canada geese that exist, their specific breeding areas, how they mingle with other races during the migration and wintering period, and to develop new management strategies based on such information. Long-term studies soon to be published on the taxonomy and racial distribution of white-cheeked geese by Harold C. Hanson of the Illinois Natural History Survey will provide the scientific basis for such future action.

Most populations of geese can be expected to do reasonably well in the future if we continue to improve our knowledge and are cautious in our management of them. We do not believe we really have the capability to manage goose populations as finitely as previous management plans and population data may suggest. We are not certain we can hope to fine-tune the system much more, without initiating extensive work on the various breeding components of the populations we are attempting to manage. The cost-effectiveness of meeting these research and management needs will determine how much we can improve our capability. Therein lies the challenge for the future. The speakers that follow will address many of these issues in greater detail based on their specific management and research experiences.

Acknowledgments

Many dedicated scientists, waterfowl biologists, managers, administrators and waterfowlers have made substantial contributions to the base of knowledge on which current goose management programs are founded. We would like to have recognized all of them, but in this background paper we could only make references to a few as we summarized the evolution of goose management in North America.

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Atlantic Flyway Goose Populations: Status and Management

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Introduction

Goose populations (*Anser* and *Branta spp.*) within the Atlantic Flyway (AF) compose about 17 percent of the geese in North America. This resource provides a subsistence harvest to natives in eastern Canada, hundreds of thousands of days of hunting recreation and unlimited nonconsumptive recreational benefits. During the past two decades greater snow goose. (*A. caerulescens atlanticus*) and Atlantic (AP) Canada goose (*B. canadensis*) populations and harvests have increased. Population increases have created conflicts in urban environments and habitat degradation where concentrations of geese occur. Despite increases in certain AF goose populations, distributional changes have occurred that resulted in inequities in harvest and nonconsumptive opportunities in certain portions of the AF. Although goose breeding and staging habitats have not been negatively impacted by human activity in the past, threats to critical goose habitats are imminent.

Populations

Five populations of geese in the AF can be managed separately. They include the greater snow goose, Atlantic brant (*Branta bernicula hrota*), and the Atlantic, Southern James Bay, and resident populations of Canada geese.

Greater Snow Goose

Greater snow geese form a discrete population which nest principally around the northern portion of Foxe Basin, northern Baffin, Bylot, Axel Heiberg, and Ellesmere islands and northwest Greenland (Heyland and Boyd 1970, Reed et al. 1980). Migration to major wintering areas along the mid-Atlantic coast from southern New Jersey to Cape Hatteras, North Carolina includes a stop in the St. Lawrence River estuary, where most of the fall flight uses a 30-mile (50 km) stretch near Cap Tourmente, and Ile aux Oies-Ile aux Grues Island, downstream from Quebec City. In spring the entire population stages briefly along a 200-mile (160 km) reach of the St. Lawrence River prior to a final movement to breeding areas.

Atlantic Brant

Atlantic brant nest primarily in the eastern Arctic, from Southampton Island and

Baffin Island north to Ellesmere Island, on northern Greenland; and more sparsely west and south to the Queen Maud Gulf. James Bay is a fall staging area and most brant migrate directly from there to wintering areas along the Atlantic coast. Brant winter principally from Long Island, New York to the Chincoteague area of Virginia. The shallow, coastal bays of southern New Jersey support 50–80 percent of the AF population. However, small flocks are found northward to Cape Cod, Massachusetts, and southward to Cape Hatteras, North Carolina.

Canada Goose

Five subspecies of Canada geese occur in the AF. Migratory flocks include the Atlantic race (*B. c. canadensis*), the interior race (*B. c. interior*), and the occasional Richardson's Canada goose (*B. c. hutchinsii*). Migrant flocks are managed as two distinct populations, the Atlantic Population (AP), and the Southern James Bay Population (SJBP), formerly the Tennessee Valley Population. Giant Canada geese (*B. c. maxima*) and western Canada geese (*B. c. moffitti*) form a third population, commonly referred to as resident geese. These subspecies have been introduced since the 1930s from liberation of decoy flocks and purposeful stocking.

Canada geese affiliated with the AP breed from Labrador and Newfoundland westward to the Ungava Peninsula of Quebec. Nesting concentrations occur around the Ungava Bay area and northeastern shore of Hudson Bay on the Ungava Peninsula (Kaczynski and Chamberlain 1968, Malecki and Trost 1988) where nesting densities are among the highest (four pair per square mile) reported for Canada goose populations in North America (Malecki and Trost 1988). Little information exists on the number and distribution of Canada geese breeding in Newfoundland and Labrador.

The AP migrates along two major corridors. The most prominent extends from the east shore of Hudson and James bays south across eastern Ontario, western Quebec, central New York and eastern Pennsylvania to the Delmarva Peninsula and eastern North Carolina (Bellrose 1980, Stotts 1983b). The other extends from the Labrador-Newfoundland coast through the Maritime Provinces and New England States to coastal areas as far south as North Carolina (Stotts 1983b). Other corridors in the interior, east of Hudson and James bays, are used by smaller numbers of geese (Heyland and Garrard 1974).

Geese affiliated with the AP winter from Ontario and Maine southward to North Carolina. The Delmarva Peninsula of the Chesapeake Bay region has been the nucleus of wintering AP geese over the past two decades. Other winter concentrations occur in portions of New York, New Jersey, Pennsylvania and Virginia.

Breeding range of the AF component of the SJBP is poorly defined. Results from recent banding operations suggest that these geese breed along the east coast of James Bay in the vicinity of the Nottaway and Rupert rivers, west to the Albany River area and on Charlton and Akimiski islands to the north (Abraham et al. 1989). Migration occurs along a corridor west of the Appalachian range extending through southern Ontario into eastern Michigan and Ohio and through western Pennsylvania and northeastern Ohio (Malecki and Trost 1986, Sheaffer and Malecki 1987). Known stopover areas include Mosquito Creek Wildlife Management Area (WMA), Ohio and Pymatuning WMA, Pennsylvania.

In the AF, geese affiliated with the SJBP winter in the Piedmont region of western North Carolina and South Carolina (Malecki and Trost 1986). These geese are associated primarily with the Pee Dee, Carolina Sandhills, and Santee national wildlife refuges (NWR).

We define resident Canada geese in the AF as geese breeding south of 47° latitude. Flocks of resident geese now occur from the Maritimes and Ontario south to Florida. Their numbers, distribution and movements in the AF are poorly understood, but are currently under investigation.

Population Monitoring

Little information is currently available to adequately assess annual productivity of AF goose populations. Annual surveys on the breeding grounds have proven too costly and impractical. In lieu of annual breeding ground surveys, spring satellite photography, combined with weather reports, has been used since 1975 to provide information regarding the extent and duration of snow and ice cover at time of nesting for important goose production areas in Arctic Canada. Examination of satellite photos can determine extremes (very poor or very good) in habitat conditions during the nesting season, but is not sensitive enough to predict productivity between these extremes. In addition, the U.S. Fish and Wildlife Service (FWS) and Canadian Wildlife Service (CWS) have conducted an aerial survey in June each year since 1987 to assess goose nesting conditions in Arctic Canada north of lattitude 60°. Observations made by banding crews provide supplemental information from key areas regarding the chronology and success of nesting seasons.

Late fall and winter surveys provide the main source of information on population trends for geese. These have been made for greater snow geese since 1950, using both visual estimates and vertical photography from aircraft. Vertical photography has been used since 1965 to census greater snow geese in both fall and spring as they stage along the St. Lawrence River estuary. The spring (May) photo census provides almost complete photographic coverage of the entire population. In addition photo counts of greater snow geese have been made in March on major wintering areas in the U.S. since 1981 (Ferrigno et al. 1990).

The midwinter waterfowl inventory (MWI), conducted annually in early January in the AF, has been the most important means of monitoring population trends and distributional changes in AF goose populations since the late 1940s. However, MWI estimates of snow geese have been significantly lower than photo counts from the St. Lawrence. These differences are probably due to observer bias (e.g., large flocks are underestimated) and insufficient coverage of inland areas. Hestbeck and Malecki (1989b) compared midwinter estimates for Canada geese with mark-resight data from states containing major winter concentrations in the AF. They concluded that the similarity of the mark-resight estimate and the MWI estimate indicated the MWI provides a good index of midwinter numbers of Canada geese.

In addition to the MWI, other aerial surveys have been conducted in the AF to monitor fall and winter populations of geese. Periodic surveys (October–March) of Atlantic brant were made between 1975–79 to monitor population size, particularly following winter kills which occurred in 1977 and 1978. Monthly surveys of Canada geese were made in the AF between September to January from 1961–70 to monitor changes in seasonal distribution. Only the mid-November survey has been retained as an operational survey.

Annual production of AF goose populations is monitored by the ratio of juvenile/adult geese in the harvest provided by FWS and CWS harvest surveys. Productivity information for snow geese is also obtained annually on the St. Lawrence staging area using ground and photo counts. Ground counts are also conducted in the U.S. to assess productivity of snow geese and brant. Data gathered from these surveys include the proportion of juveniles in the fall flight and mean brood size, and are used for estimating the total fall flight of brant and snow geese.

Banding studies of brant and snow geese have been used to determine migration corridors, migration chronology, and harvest distribution. Because of the difficulty and expense of banding on the breeding grounds, other population parameters derived from band recovery information are lacking There is no operational banding of either snow geese or brant in the AF.

Data from banding studies of Canada geese are extensive in the AF (Heyland and Garrard 1974, Ferguson 1975, Hanson and Smith 1950, Evans 1956, Evans 1960, Crider 1967, Addy and Heyland 1968, Florschutz 1975, Luszcz 1980, Stotts 1983b, Trost et al. 1985, Malecki and Trost 1986, Harvey 1987). Between 1983–86 over 28,000 Canada geese were marked with leg and neckbands. Results from this effort have been used to rigorously define population parameters and distributional changes of AF Canada geese (Malecki and Trost 1986, Hestbeck and Malecki 1989a, Hestbeck et al. 1990).

Population Trends

Greater Snow Goose

The greater snow goose population has increased dramatically since the turn of the century. Midwinter estimates have climbed from 41,800 in 1950 to 198,000 in 1988 (Figure 1). Although MWI estimates have tracked the remarkable upward trend in snow goose numbers, spring photo counts in the St. Lawrence have recorded substantially greater numbers of geese. Spring survey estimates have increased from 25,400 in 1965 to 364,000 in 1988 (Figure 1). The increase in snow geese has led to an expansion of breeding, staging and wintering range as well as adaptation to new types of feeding habitats, i.e., upland agricultural fields adjacent to staging and wintering areas. Unlike brant, which are confined to a small wintering area, snow geese now move considerable distances inland to feed on agricultural crops, increasing the carrying capacity of their wintering grounds.

It appeared that greater snow goose numbers were stabilizing at approximately 170,000 during the early 1980s, probably as a function of greater harvest rate. However, the population has since increased dramatically while harvest rates have dropped. Reed (1989), using population models, indicated no evidence of increasing density-dependent factors within the population to suggest either stabilization or decline in the near future. To the contrary, his analysis indicated that the greater snow goose population will likely continue to increase during the 1990s, increasing overuse of coastal marshes, the St. Lawrence staging area, and wintering grounds.

Small flocks of lesser snow geese (*A. c. caerulescens*) occur in close proximity to greater snow geese, but their numbers are not significant. This subspecies has traditionally occurred in small flocks where up to 60 percent of the flock was composed of blue-phase birds. Fewer than 4,000 lesser snows winter at Blackwater,

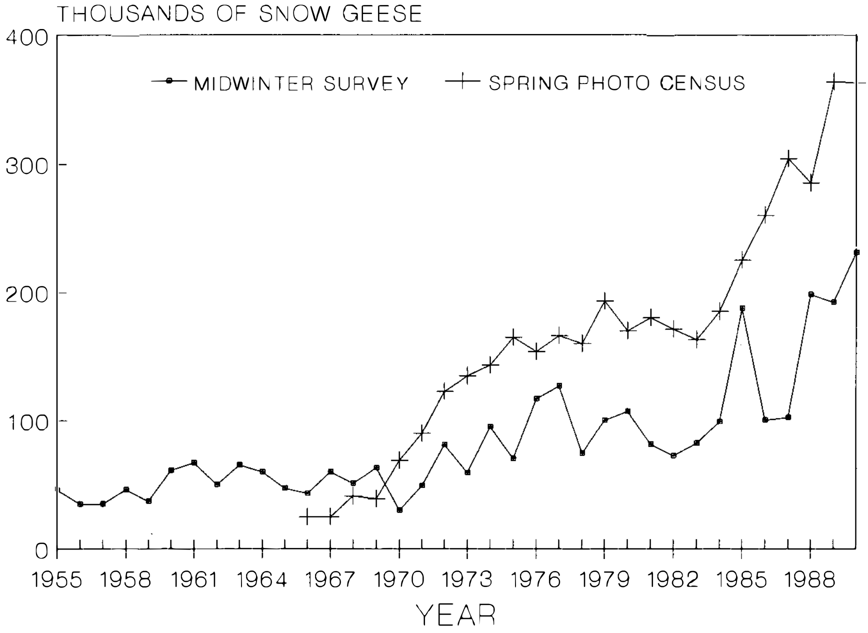

Figure 1. Midwinter estimates and spring photo census of greater snow geese in the Atlantic Flyway, 1955–90.

Presquile, Mattamuskeet, and Cape Romain NWRs. Lesser snow geese now mix with greater snows on major wintering areas making it virtually impossible to obtain a population index for lesser snow geese. Less than 1 percent of the snow geese which stage at Cap Tourmente, Quebec, display blue plumage (A. Reed and H. Boyd, personal files: 1981). Approximately 3 percent of the snow geese harvested in this area, are lesser snows, as judged by culmen measurements (A. Reed, personal files: 1981).

Atlantic Brant

Unfavorable habitat conditions on the breeding grounds, such as delayed snow melt or severe summer storms, often cause large fluctuations in Atlantic brant productivity and population size. Winters with prolonged snow and ice cover can cause drastic reductions in brant numbers when food is unavailable. Less severe winters may still result in some winter starvation if sea lettuce (*Ulva lactuca*), currently their principal food, is scarce.

Atlantic brant numbers decreased alarmingly in the early 1930s, attributed at the time to a calamitous reduction in eelgrass (*Zostera marina*), their principal food (Lincoln 1950). Brant numbers along the Atlantic coast during the winter of 1933–34 comprised only 10 percent of that in 1930–31 (Cottam et al. 1944). The population recovered in the 1940s, peaked in the late 1950s and early 1960s and remained high until the 1970s (Figure 2). Two successive years of reproductive failure (1971 and 1972) coupled with a high harvest in 1971 reduced the population to 41,000 in 1973.

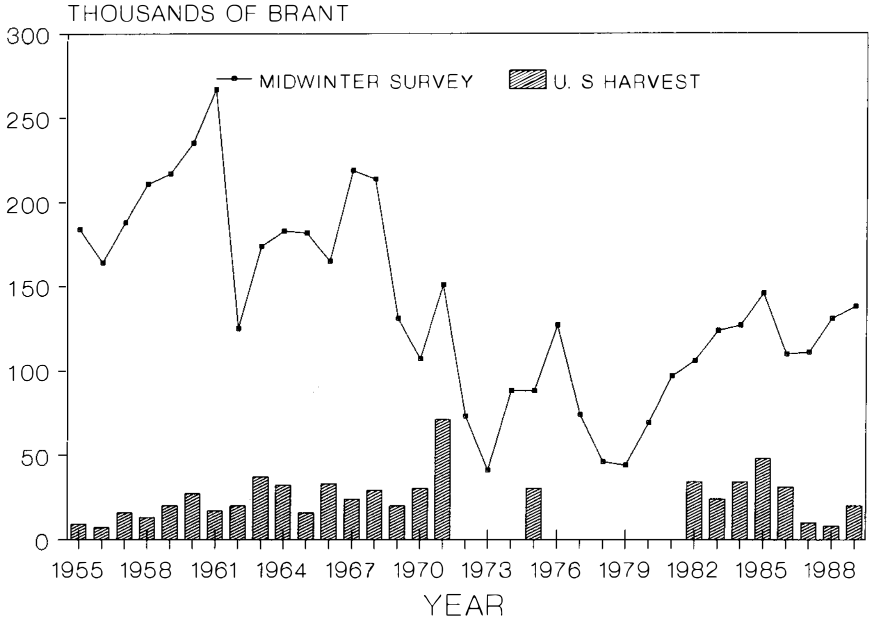

Figure 2. Midwinter survey and harvest estimates of Atlantic brant in the Atlantic flyway, 1955–89.

Brant increased to approximately 125,000 in the fall of 1976, but suffered severe winter mortality in late January–early February, 1977. Winter losses were estimated at 81,000 (Myers et al. 1982). Brant have since recovered, averaging 123,000 birds on the MWI during the 1980s.

Canada Goose

Numbers of Canada geese in the AF have increased dramatically over the last 40 years (Figure 3). However, the number of birds in the fall flight or size of the breeding population is poorly documented. It is generally accepted that over 1 million Canada geese occur in the AF fall flight. Midwinter estimates averaged 604,400 during 1948–90, ranging from a low of 148,400 in 1948 to a high of 955,000 in 1981 (Figure 3). The dramatic increase of Canada geese appears to be related to their ability to exploit abundant food in agricultural areas of the Delmarva Peninsula.

Canada goose numbers in the AF stabilized in the 1980s and recently have declined (Figure 3). The proportional decline of AP geese in this estimate may be more significant, being masked by increasing flocks of resident Canada geese that cannot be distinguished in the MWI.

Changes in the distribution of wintering Canada geese continue to occur (Figure 4). Numbers of geese in New England increased between 1962–90, but the increase has not been in excess of the increase observed in the AF as a whole (Trost and Malecki 1985). In the mid-Atlantic region (New York, New Jersey, Pennsylvania), Canada geese have increased markedly since 1962 (Figure 4). The rate of increase for this

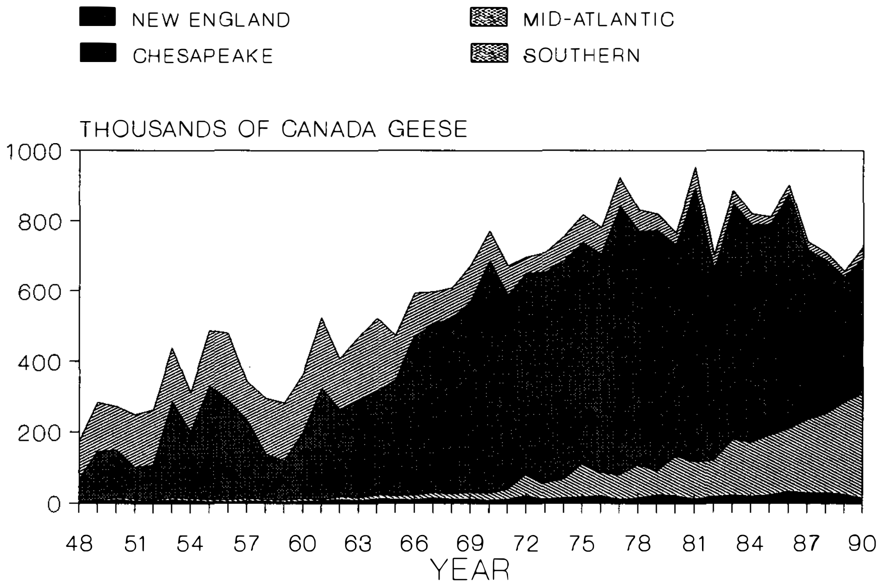

Figure 3. Midwinter survey distribution of Canada geese in the Atlantic Flyway, 1948–90.

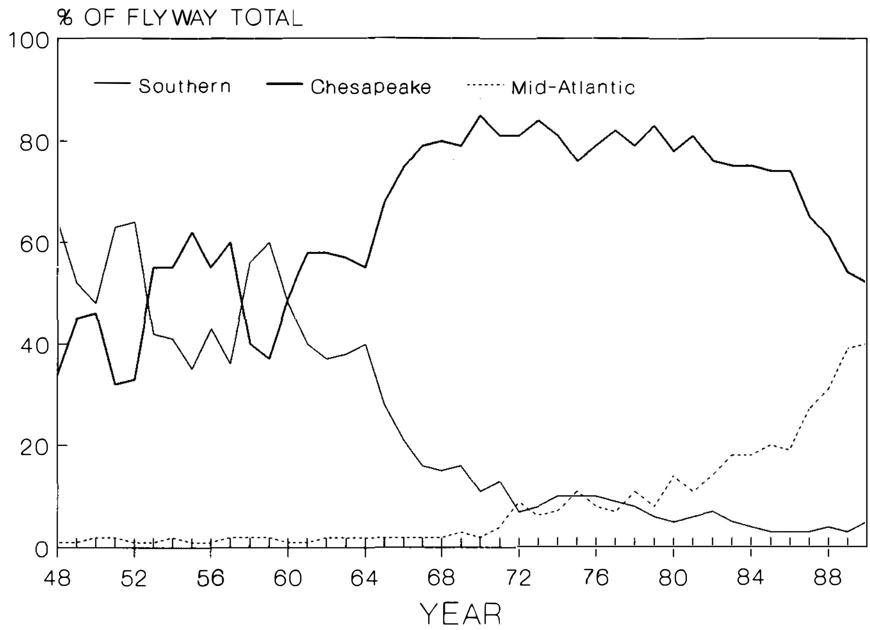

Figure 4. Changes in the proportional distribution of Canada geese wintering in three regions of the Atlantic Flyway, 1948–1990.

region has been greater than that for the AF as a whole. This may be, in part, due to increases in resident geese.

Canada geese increased rapidly in the Chesapeake region (Maryland, Delaware, Virginia) during the early 1960s, but numbers are now declining on the Delmarva Peninsula (Figure 4). During the 1970s and early 1980s over 80 percent of the AF MWI estimate occurred in this region.

While Canada geese in the AF increased after the mid-1960s, Canada geese in the southern region (North and South Carolina) have declined and currently number only about 25,100. Most of these are AP Canada geese, but include several thousand SJBP and resident Canada geese.

Resident Canada goose flocks in the AF appear to be increasing, although their population dynamics are poorly understood (Castelli 1987, Chasko and Merola 1987, Heusmann 1989, Luszcz 1989, Dewberry 1989, Swift 1990). However, Sheaffer et al. (1987) estimated that only one of three resident goose populations in New York were increasing. Results of current research in the AF estimated the number of resident breeding pairs in nine AF states and Ontario in 1989 at 52,035, which represents about 25 percent of the breeding component of the flyway Canada goose population (R. Malecki, pers. comm.: 1990).

Harvest Trends

Greater Snow Goose

Greater snow geese provide hunting opportunities in the U.S. and Canada, primarily in coastal New Jersey, the Delmarva Peninsula, and coastal North Carolina in the U.S., and the St. Lawrence River in Quebec. The entire Canadian sport harvest of greater snow geese occurs along the St. Lawrence River. Harvest increased as the population expanded and harvest regulations were liberalized (Figure 5). Annual changes in AF harvests fluctuate with the proportion of juveniles in the fall flight (Figure 5).

Taking of greater snow geese and their eggs for subsistence is restricted to a small number of Inuit natives. Subsistence harvest is not well documented, but must be small in view of the remoteness of most nesting colonies from native settlements and the emphasis the Inuit place on the hunting of marine mammals.

Atlantic Brant

Brant harvests in the U.S. have fluctuated from 13,000 in 1958 to 71,000 in 1971 (Figure 2). Hunting seasons for brant were closed in the U.S. in 1972–74 and again between 1976–80. A small subsistance harvest of brant occurs on Hudson and James bays, Quebec, resulting in a Canadian harvest that rarely exceeds 1,000 birds.

Canada Goose

The Canada goose is the most commonly harvested waterfowl species in the AF. The AF Canada goose sport harvest has increased in both the U.S. and Canada, currently totaling about 427,400 birds annually (Figure 6). Most of the AF harvest is composed of geese affiliated with the AP. Until 1984 the harvest had been increasing everywhere in the AF, except in Nova Scotia, New Brunswick and North Carolina southward. Restrictive harvest regulations in Maryland, Delaware and North

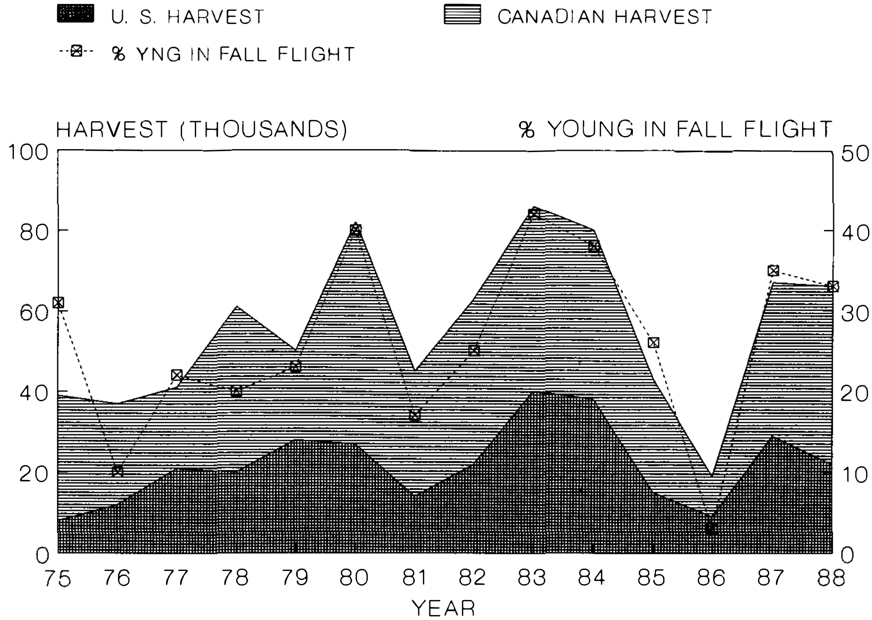

Figure 5. Harvest of greater snow geese in the Atlantic Flyway, 1975–1988.

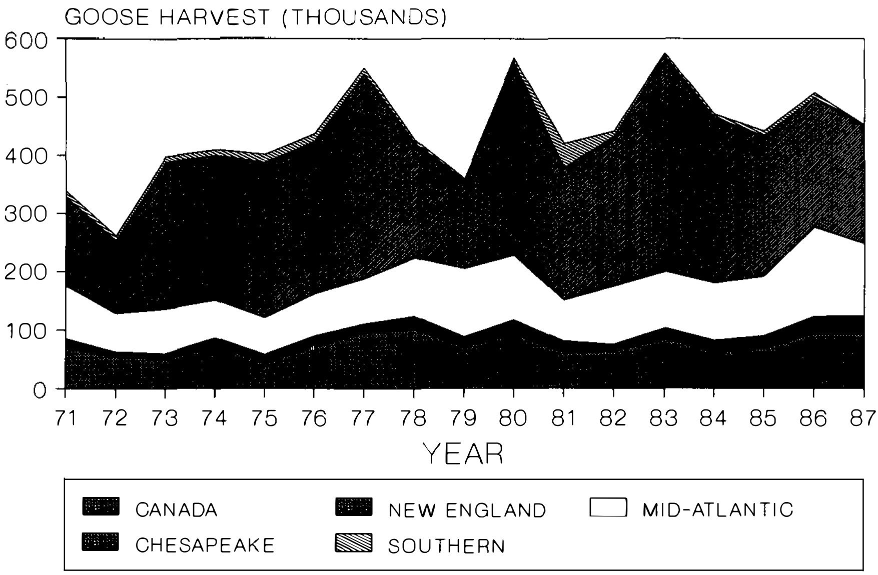

Figure 6. Harvest of Canada geese in the Atlantic Flyway, 1971–1987.

Carolina, combined with reduced fall flights, have reduced harvest levels in the AF since 1986.

Subsistence hunting of AF Canada geese on the breeding grounds has been estimated between 60,000 and 80,000 birds annually (Addy and Heyland 1968, Boyd 1977, C. A. Drolet pers. comm.: 1988). Cree Indians account for 75–80 percent of the native harvest, mainly in James Bay during spring migration. The remainder is spread among coastal Inuit settlements located on the Ungava Peninsula (James Bay and Northern Quebec Native Harvesting Research Committee 1979).

The proportion of SJBP geese in the AF goose harvest is unknown. Geese affiliated with the SJBP are harvested in Ontario, eastern Michigan, Ohio, Kentucky, Tennessee and Alabama in the Mississippi Flyway (MF), and Pennsylvania and possibly Virginia in the AF. Harvest restrictions in southern areas in the AF have reduced or eliminated harvest of SJBP geese on their wintering areas during the past eight years. Significance of subsistence hunting on SJBP geese affiliated with the AF is unknown.

Harvest levels of resident geese in the AF are also unknown, but are likely increasing due to increases in resident goose flocks and the recent implementation of experimental, resident goose seasons in several states. Average annual harvest of resident geese in Connecticut and Massachusetts during experimental seasons between 1987–89 was 2,281 birds (Chasko and Merola 1989, Heusmann 1989). Resident geese from New York contribute to the harvest in Ontario, New York, Pennsylvania, Maryland and Delaware (Sheaffer et al. 1987). Geese that migrated out of New York had lower survival rates than those that remained within the state.

Harvest Management

Goose management in the AF has been guided by the mandate of the Migratory Bird Treaty Act of 1918 to ensure preservation of identified stocks of migratory birds and to strive towards the maintenance of population levels that optimize resource benefits to man. Waterfowl managers in the AF have placed emphasis on management directed at maximizing opportunities for sport hunting, while maintaining the subsistence and non-consumptive uses of the goose resource.

Greater Snow Goose

Harvest management of greater snow geese is dependent upon maintaining a spring population level of not less than 120,000 birds as measured by the spring photo census (Canadian Wildlife Service et al. 1981). This objective ensures a fall population large enough to sustain a sport harvest following a poor breeding season. A season closure would be considered when a spring population of 120,000 or less experiences a very poor breeding season. A maximum spring population objective of 180,000 was identified in 1984 in regional and national U.S. waterfowl management plans, but attempts to stabilize the population at this level have been unsuccessful. The present population exceeds the current objective of 185,000 birds (Environment Canada and U.S. Department of the Interior 1986).

Although harvest regulations for snow geese have been liberalized in both the U.S. and Canada, harvest rates have declined and harvest increases have failed to stabilize numbers. Following season closure for 31 years in the U.S., a 30-day season with a daily bag limit of 2 geese was allowed in 1975, and was expanded to 90 days/4 geese between 1981–88 and 90 days/5 geese in 1989. Limited access to private lands, large flock size, difficulty in hunting tidal marshes, and lack of knowledge of snow goose hunting tactics have kept U.S. harvest low. However, demand for snow goose hunting is increasing in the U.S., and remains high along the St. Lawrence River.

Atlantic Brant

In 1977 the Atlantic Waterfowl Council (AWC) approved of managing brant by the Population Level (PL) System. Under the PL system, post-hunting season populations have been managed between 100,000 and 150,000 birds. In the past, production busts have reduced brant numbers to lower levels of this range, and winter carrying capacity and starvation have stabilized brant numbers at the upper limits. Hunting regulations range from restrictive (30 days/2 birds) at a population size of less than 130,000 birds to liberal (50 days/4 birds) at high population levels. The current population objective for this species is 124,000 (Environment Canada and U.S. Department of the Interior 1986).

Canada Goose

Prior to the development of the first management plan for AF Canada geese in 1983, population objectives included: (1) an increase in the wintering population to 750,000 to 1,000,000 birds and (2) a more equitable distribution of kill and hunting opportunity (Addy and Heyland 1968). Management objectives adopted in 1983 attempted to address the continuing decline of southern Canada goose flocks while maintaining northern flocks at high levels (Stotts 1983a). However, harvest recommendations made by the AWC's Canada Goose Subcommittee to reduce the impacts of harvest in northern states upon southern birds were not adopted because of a lack of information. An improved data base, resulting from the AF Canada goose banding project, and recent declines in AP geese prompted the development of an updated management plan for AF Canada goose populations in 1989. Although this plan has not yet been formally adopted by the AWC or FWS, current harvest regulations adhere to the plan's management objectives. Proposed population objectives include: (1) maintain an average winter population of 725,000 AP geese; (2) increase the numbers of AP geese wintering in the Southern region of the AF and (3) provide equitable and reasonable opportunities for sustained recreational harvest (Atlantic Waterfowl Council 1990).

Harvest regulations for AP Canada geese have become more liberal since the late 1940s as the numbers of geese in the flyway increased. From 1945 to 1954, bag limits averaged two birds, while season length varied from 30–60 days throughout the flyway. In 1955 season length was increased to 70 days with a limit of two geese daily. In response to an increase in population size, regulations were again liberalized in 1969 to allow a daily bag limit of three geese. During the early 1970s the goose flock increased on the Delmarva Peninsula and southeastern Pennsylvania to the point where many farmers were complaining about crop damage. In response to those complaints, season length was increased to 90 days, extended to 31 January, and the bag limit raised to four in 1977. Maryland, the major harvest area in the AF, retained the three goose bag limit. A small number of states in the mid-Atlantic and New England regions have since been permitted 90-day seasons.

Harvest regulations have become more restrictive in Maryland and Delaware since 1986 in response to a decline in Canada goose numbers. This decline has been attributed to a combination of successive years of low annual production and high harvest rates. Harvest regulations were reduced by state action to 52 days, with a staggered limit of one and two geese in Maryland and 45 days/2 geese in Delaware in 1989.

In the southern region, regulations have been increasingly restrictive in an effort to reverse the decline in AP and SJBP geese. Goose hunting has not been permitted in Georgia or Florida since 1974. South Carolina closed goose hunting by state action in 1985, while North Carolina limited the bag limit to one goose and season length to 43 days in 1981, 17 days in 1986, and 11 days in 1988. Goose hunting has been closed in western North Carolina since 1987 to afford protection to SJBP geese. Harvest regulations have also remained conservative in western Pennsylvania since this area has been identified as a major migration stopover for SJBP birds.

Resident Canada geese are a valuable resource for public viewing and hunting opportunities in areas that may not winter migrants. Resident geese in portions of Georgia and North Carolina have increased to levels that can sustain a limited sport harvest. In 1989 both states held experimental, resident goose seasons aimed at providing recreational opportunities. The season in North Carolina was restricted to September 1–10 prior to the arrival of migrant geese. Since migrant Canada geese winter in Georgia in insignificant numbers they were allowed an experimental, eight-day resident goose season beginning in January 1990.

Management Issues of Concern

Survey Needs

Knowledge of the proportion of juvenile geese in the fall flight is an essential element of annual harvest regulations. Satellite photography and weather reports can determine extremes in habitat conditions during the nesting season and provide an indication of nesting success, but they are not sensitive to small changes in habitat conditions. Therefore, it has been difficult to provide a reliable estimate of fall goose populations prior to the setting of harvest regulations. Developing a methodology to assess annual recruitment should receive high priority within the plans of the Arctic Goose Joint Venture.

Attaining and maintaining population goals depends on accurate monitoring of population size, harvest and the effects of harvest regulations. Low band-recovery rates have hampered our ability to refine harvest regulations because of poor reliability in the interpretation of harvest data. Use of mark-resight data in the AF since 1984 has provided reliable information regarding effects of restrictive harvest regulation changes on survival and recovery rates for Canada geese in North Carolina (J. B. Hestbeck, pers. comm.: 1990). Restrictive harvest regulations in the Chesapeake region since 1988 were directed at improving survival rates. However, neckbanding of Canada geese ended in 1986 and although an extensive observation effort has continued thru 1989 throughout the major winter areas, observations are not planned beyond February, 1990. Effects of these regulation changes upon survival cannot be evaluated adequately without a sustained mark-resight effort or improvements in our banding program in the AF.

Harvest estimates of geese in the U.S. are hampered by small sample size (Tautin et al. 1989). Improvements to the FWS Questionnaire Survey of U.S. Waterfowl

Hunters and the Parts Collection Survey are needed for geese rather than ''piggy-backing'' on a duck harvest survey. The technology to estimate harvest by goose population and region needs to be developed.

Nuisance Canada Geese

Increasing numbers of resident geese have caused nuisance problems in urban and suburban areas. Large numbers of both migrant and resident geese in association with private residences, public water reservoirs, golf courses, parks and airports can cause human health hazards and inconvenience. Resident geese have also caused damage to gardens, golf courses, winter cover and hay crops. Control methods, including anti-feeding ordinances, harassment, relocation, physical barriers, chemical repellents, nest manipulations, sterilization and habitat modification by state, provincial and local governments have been costly and generally ineffective in providing long-term control.

Problems created by resident geese have been resolved by trapping and relocating juveniles and moulting adults. Donor states have included Connecticut, New York, New Jersey, Delaware, Pennsylvania and Maryland. The Ontario Ministry of Natural Resources has been removing 350 to 600 goose eggs annually from nests in southern Ontario since the late 1970s to help control population growth of resident geese and to supply stock to establish breeding Canada geese in southern MF states (M. Eckersley, pers. comm.: 1990). Resident geese have been used to establish local flocks in Maine, West Virginia and Georgia, and to off-set the decline of migrant geese in the Carolinas. Presently, interest in relocating resident geese has decreased.

The AWC's policy has been to use hunting as a tool to reduce nuisance goose populations where practical, and to relocate problem geese to other parts of the flyway (Atlantic Waterfowl Council 1981). Since 1978, 90-day seasons have been permitted in parts of New York, New Jersey, Connecticut and Rhode Island to reduce nuisance levels of geese. In 1987 the AWC developed guidelines for conducting experimental, resident goose seasons, which permitted an extension of the framework dates to 5 February and a five-bird daily bag limit during the last 15 days of the season. These guidelines required that resident goose seasons would have little effect on migrant geese. Draft criteria for experimental, resident Canada goose seasons were developed by the FWS from these and similar guidelines developed by the Mississippi Flyway Council (MFC) (*Federal Register* June 27, 1987).

Since 1987, late resident goose seasons have been permitted in the coastal zones of Connecticut and Massachusetts. In northern AF states inland water bodies freeze-up in late winter, forcing resident flocks to coastal waters where they are more vulnerable to hunters. Although the impact of this harvest technique on population size or growth is inconclusive, it appears to have potential for increasing harvest rates on nuisance flocks (Chasko and Merola 1989). Preliminary results suggest the impact of these experimental seasons on migrant populations is negligible.

New York has proposed a 10-day September resident Canada goose hunt in a 340 square mile (881 km^2) area of the St. Lawrence River Valley in 1990 to reduce nuisance and public health problems and agricultural damage caused by a rapidly expanding resident flock (Swift 1990). Ontario is considering a concurrent season for the same purpose. Massachusetts has also requested an early September resident goose season in 1990 within their Berkshire Zone.

Habitat Degradation by Snow Geese

The tremendous increase of greater snow geese in the AF has created problems. The root systems of saltmarsh cordgrass (*Spartina alterniflora*) and saltmarsh bulrush (*Scirpus robustis*) are damaged where concentrations of feeding snow geese occur. Marsh degradation by snow geese is a serious threat to black duck production and wintering areas, especially the Delaware Bay saltmarshes. Destruction of emergent saltmarsh vegetation results in denuded areas termed "eat-outs." Large expanses of once densely vegetated tidal saltmarsh now stand as patchy growths of a saltmarsh cordgrass amid mudflats. Eat-outs are also responsible for a loss of clapper rail (*Rallus longirostris crepitans*) nesting habitat (Widjeskog 1978), and a reduction of saltmarsh snails (*Melampus bidentatus*), an important winter food of American black ducks (*Anas rubripes*). For example, average saltmarsh snail densities decreased from 916 snails per square yard ($837/m^2$) from control sites to 22 snails per square yard ($20/m^2$) from snow goose eat-outs in coastal New Jersey (Ferrigno 1990). Eat-outs are believed to reduce winter carrying capacity for black ducks and to increase erosion in exposed marshes (Ferrigno 1990). Severe saltmarsh eat-outs have occurred primarily on Brigantine NWR in New Jersey and Bombay Hook NWR, Prime Hook NWR and Little Creek WMA in Delaware.

Hazing tactics have largely been ineffective in minimizing snow goose damage. In response to this problem, goose hunting has been permitted on certain parts of Bombay Hook NWR since 1983 as a means of dispersing birds. In 1988 Delaware was permitted a 10-day experimental snow goose season on Bombay Hook NWR prior to the traditional opening of the statewide 90-day snow goose season. This experimental season was expanded to the state-owned Little Creek WMA adjacent to Bombay Hook NWR in 1989. Although hunting pressure has been effective in reducing eat-outs during part of the fall and winter, overgrazing occurs when hunting pressure declines. Maintaining an adequate number of hunters on these areas to disperse snow geese has been difficult (F. Smith, pers. comm.: 1990).

Snow goose damage to winter cover crops on the Delmarva Peninsula has also become a problem that has been addressed with increased technical assistance to farmers and hunting regulation liberalization. Higher populations have increased nesting densities on Bylot Island, Northwest Territories, resulting in increased grazing but without eat-out problems (A. Reed, pers. comm.: 1990).

Decline of Southern Canada Geese

The issue of primary concern regarding goose populations in the AF has been the decline of migrant Canada geese wintering in the southern region. This region accounted for 51 percent of the Canada geese in the AF in 1948–55, with 40 percent occurring in North and South Carolina (Figure 4). Currently, this region supports less than 5 percent of the AF total. In Georgia and Florida, major declines occurred between 1953 and 1960, whereas the North and South Carolina numbers have diminished since the early 1960s. Presently, the Carolinas winter about 25,000 geese, the majority of which are affiliated with the AP. No AP geese are known to exist in Georgia and Florida.

Small differences in survival rates between geese banded in Maryland and North Carolina during 1963–74 were insufficient to account for the change in goose distribution observed during this period (Trost et al. 1986). Habitat changes within the

AF, including larger farms and increases in corn acreage have paralleled the northward redistribution of geese (Malecki et al. 1988). Analysis of more recent data, however, indicates that changes in the distribution of geese among regions of the AF during the 1980s are related primarily to annual survival rates rather than to shifting of individual geese between regions (Hestbeck and Malecki 1989, Hestbeck et al. 1990). Regulations have become increasingly restrictive in an effort to reduce harvest and increase annual survival.

Restrictive harvest regulations in northern AF states to effect recovery of AP geese in the southern region has been difficult to achieve. Delaying the goose season in areas used by southern birds is a technique suggested to enhance their passage and survival to southern termini (Crider 1967, Luszcz 1980). However, timing and movement of southern geese through the AF has been unknown until recently (Hestbeck et al. 1990). Maryland has delayed opening dates until mid-November since 1986, while season dates have been delayed until mid-October in southeastern Pennsylvania, New York and New Jersey since 1988.

Decline of Atlantic Population Canada Geese

An issue of recent concern in the AF has been the decline of AP geese. Trost and Malecki (1985) first documented the slowdown in population growth rate, indicating that numbers of Canada geese in the AF appeared to be stabilizing due to steadily increasing harvest rates, not a decline in recruitment. They further indicated that changes in the proportional distribution of AF geese were likely to continue in the absence of changes in current harvest management practices.

Between 1987 and 1988, MWI estimates of Canada geese in the AF fell below 750,000 birds. This figure included approximately 98,700 resident geese (Malecki 1985). Managers became concerned that numbers of resident geese may be masking a more significant decline in AP numbers. Large declines occurred in MWI estimates of geese in Maryland and Delaware, states which have few resident geese. Annual survival rate estimates of migrant Canada geese from the Chesapeake region declined from 75.6 percent to 64.7 percent between 1984–86 (Hestbeck and Malecki 1989). High harvest rates combined with poor annual production since 1984 are believed to be the causes of the AP decline.

In 1988, new management objectives were developed for AF Canada geese (Atlantic Waterfowl Council 1990). Harvest regulations were adopted in the mid-Atlantic and Chesapeake regions to reduce harvest by 15 percent to achieve and maintain a three-year average midwinter population of 725,000 AP geese in the AF. In 1988, Maryland and Delaware selected harvest regulations more restrictive than those adopted by the AWC and FWS in an effort to reverse the decline of AP geese wintering in their states. Preliminary results suggest that estimated harvest rates in Maryland have decreased to a level which should allow population recovery when annual recruitment improves (Hindman 1989).

Degradation of Staging and Breeding Habitats

The expansion of hydroelectric power projects in the Quebec portion of James and Hudson Bays may cause serious future problems for Atlantic brant and AP Canada geese. Three mega-hydroelectric projects are planned by Hydro-Quebec during the next 15 years. These are likely to cover 135,135 square miles (350,000 km^2) of northwestern Quebec, encompassing the southern tip of James Bay northward along the Quebec shore of Hudson Bay, extending eastward into Labrador (A. Reed, pers. comm.: 1990).

Management of reservoirs created by these projects results in fluctuating water levels that prevent the establishment of emergent vegetation along the shoreline. Emergent wetlands associated with the meanders of smaller rivers disappear as water is diverted into larger river basins. Small ponds between rivers may remain intact and serve as alternate nesting habitat for displaced Canada geese. However, habitat suitability of these ponds for nesting Canada geese is unknown. Potential for decreased densities of Canada geese throughout this region is high (A. Reed, pers. comm.: 1990). Furthermore, it is likely that estuarine habitats along the coast of James Bay will disappear due to the discharge of freshwater from these reservoirs. This may have a detrimental impact on Atlantic brant that depend heavily on eelgrass beds along the James Bay coast during fall staging.

The coastal habitat of James Bay is also threatened by the proposed diking of its northern edge to create a freshwater supply to the Great Lakes region. This project would end tidal fluctuation and could spell disaster for Atlantic brant and severely impact other waterfowl that utilize these habitats.

Future Management

The future of goose populations in the AF is dependent upon minimizing the impacts of fossil fuel and hydroelectric exploration and development within subarctic and Arctic Canada, as well as burgeoning human populations along the Atlantic coast. Critical staging and winter habitats need to be safeguarded from human degradation and development. Management of goose populations in the future will place greater emphasis on the management of breeding populations, requiring reliable estimates of breeding population size and annual recruitment. Improved population management requires increasing band recovery rates and periodic use of auxillary markers to determine reliable estimates of survival. It will also require improved estimates of harvests.

Snow geese will likely continue to increase, with harvest regulations becoming more liberal, although harvest rates continue to decline. Recreational use of snow geese can be expected to increase in the 1990s. Development of methods to minimize damage to winter habitats caused by increasing snow goose numbers will be needed.

Improved management of Atlantic brant in the 1990s will require a reliable estimate of recruitment, fall population size and harvest.

Numbers of resident Canada geese and associated nuisance problems will continue to increase as they adapt to further urban development. An aggressive approach is needed to resolve these conflicts, including nest manipulations, euthanasia and the development of hunting opportunities in nontraditional habitats, i.e., golf courses, corporate lands and sanctuaries.

Increases in resident geese in the South and other areas previously unused by winter migrants will provide increased recreational opportunities. This may partially substitute for lost hunting opportunities associated with declines of southern migrants. Special resident goose seasons can be expected to expand to southern Ontario, New England and mid-Atlantic states in the next decade. Further research to provide reliable estimates of population size and other population parameters is needed to allow independent management of migrant and resident Canada geese.

The future of SJBP geese affiliated with the AF is uncertain. Although this cohort seems to have stabilized since 1987, population increase probably will not occur without additional changes in harvest regulations in both the AF and MF. Mark-resight data from neckbanding SJBP geese between 1990–95 should identify important migration staging and wintering areas. This should enhance the information upon which decisions for harvest strategies can be made.

Canada geese affiliated with the AP are expected to increase, reaching the management objective of 725,000 birds with successive years of improved recruitment. Although wintering numbers of geese in the Chesapeake region are expected to increase, they likely will not be restored to peak levels experienced in the late 1970s. Loss of important wintering habitat will result in this cohort stabilizing at a lower level.

The future of AF goose populations is encouraging. Successful management, however, will require a stronger Federal commitment of leadership and funding to management goals and objectives. Management of geese based upon breeding populations will require increased funding through implementation of the Arctic Goose Joint Venture under the North American Waterfowl Management Plan.

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Goose Management: The Mississippi Flyway Perspective

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Introduction

Goose management has been a priority concern in the Mississippi Flyway for at least 40 years. Many of the high points of waterfowl management in the Mississippi Flyway have involved geese. These successes resulted from long-range planning, well-designed and -directed research efforts, and a cooperative approach to managing these shared resources. Because of these efforts, we enter the 1990s with record numbers of geese. However, there have been downsides to goose management in some geographical regions because of changes in migration and wintering patterns. We question whether geese can be managed in the context of "traditional" migration and harvest. Changes in agriculture, wetland losses and degradation, and increases in goose populations have affected the nature of goose biology and management in the Mississippi Flyway. The challenge for the future will be to address the dynamics of goose distribution by cooperatively developing realistic and applicable management strategies that are based upon sound data.

Historical Perspective

The Mississippi Flyway hosts populations of white-fronted geese (*Anser albifrons*), lesser snow geese (*Chen caerulescens*) and Canada geese (*Branta canadensis*). Attention given by waterfowl managers has varied greatly among these three species.

White-fronted Geese

White-fronted geese in the Mississippi Flyway are associated with the eastern segment of the Mid-Continent Population. Distribution is confined to the extreme western fringe of the flyway, with the large majority of use occurring in Louisiana during the wintering period. White-fronted goose populations in the Mississippi Flyway increased from 39,300 in 1970 to 116,500 by 1988 (Table 1). Guidelines for management of Mid-Continent white-fronted geese were developed in cooperation with the Central Flyway during the early 1980s for a winter population of 50,000–80,000 birds (Bateman and Schroeder 1982). The majority (93 percent) of the 10,100 to 94,900 white-fronts harvested in the Mississippi Flyway (1969–88, Table 2) has occurred in Louisiana. Except for population and harvest surveys, little research attention has been given to white-fronted geese in the flyway.

Table 1. Mississippi Flyway goose populations (1000s), 1969–89[a]

Year	Canada geese					Snow geese	White-front
	Total	Giant	EPP	MVP	TVP		
1989	1850	272	325	1098	159	1041	103
1988	1353	252	184	735	170	1358	116
1987	1186	226	228	566	159	1015	77
1986	1064	232	183	515	130	1013	72
1985	1128	180	169	619	158	618	79
1984	935	152	168	477	129	923	81
1983	754	104	163	353	130	589	70
1982	803	150	213	304	130	832	62
1981	634	108	145	251	118	868	66
1980	745	103	151	367	120	505	68
1979	780	86	172	395	127	594	59
1978	862	77	207	434	143	513	49
1977	1086	60	270	576	180	794	53
1976	921	58	254	478	130	571	50
1975	687	62	204	305	116	692	53
1974	660	57	197	304	101	442	40
1973	677	58	206	278	136	532	43
1972	633	54	181	296	101	532	43
1971	625	56	157	294	118	937	46
1970	610	64	126	292	127	655	39
1969	589	51	107	325	127	425	51

[a]From the Mid-December Goose Survey; totals for Canada geese do not include TGPP.

Lesser Snow Geese

Lesser snow geese also are primarily associated with the western portion of the Mississippi Flyway; however, their range is more extensive than that for white-fronted geese. Recent shifts in the wintering range have been documented, and population sizes and harvests are significant in several flyway states, including Minnesota, Iowa, Missouri, Louisiana and, more recently, Arkansas.

Lesser snow goose populations have generally increased during the past two decades from 424,600 in 1969 to 1,358,000 by 1988 (Table 1). The objective for Mid-Continent snow geese is for a breeding population of 800,000–1,200,000 birds (Bishop and Hyland 1982).

Historically, fall migration occurred in a methodical, uninterrupted pattern to wintering grounds in coastal wetlands of Louisiana. Since the 1960s, lesser show geese have utilized state and federal management areas in Iowa and Missouri in increasing numbers during the fall. Also, during this period snow geese have shown a tendency to abandon coastal marshes in Louisiana in favor of inland rice fields and pastures (Bateman et al. 1985). Winter use of similar habitats in northeastern Louisiana, eastern Arkansas and southeastern Missouri also has increased in recent years. For example, numbers of snow geese surveyed in Arkansas in mid-December increased from an average of 6,800 during 1975–79 to 182,200 during 1985–89.

Shifts in migration and wintering patterns during the 1960s and 1970s paralleled changes in distribution among Arctic nesting colonies (Dzubin et al. 1973). New

Table 2. Mississippi Flyway goose harvest (1000s), 1969–88[a]

Year	Canada geese	Snow geese	White-front
1988	394	46	29
1987	320	57	32
1986	337	70	34
1985	336	99	47
1984	310	102	67
1983	289	187	62
1982	290	128	51
1981	309	111	95
1980	316	145	28
1979	325	166	29
1978	426	134	33
1977	358	127	19
1976	341	102	22
1975	330	168	29
1974	289	173	10
1973	220	153	33
1972	166	109	13
1971	194	160	20
1970	193	258	40
1969	190	205	38

[a]From the U.S. Fish and Wildlife Service Waterfowl Harvest Survey.

colonies along Hudson Bay were becoming established or expanding in range and size.

A peak harvest of 258,400 snow geese occurred in the Mississippi Flyway in 1970, an increase of nearly 600 percent from the 1962 harvest of 37,300 snow geese (Gamble 1989). Flyway harvests in the 1980s ranged from 46,300 (1988) to 187,300 (1983) and averaged 105,100 per year (Table 2). Primary harvest areas have been fairly consistent with population distribution. For example, in 1988, 98 percent of the Mississippi Flyway harvest of lesser snow geese was recorded in the western tier states. These same areas accounted for 98 percent of the snow geese recorded during the 1988 December Goose Survey. Typically, Louisiana accounts for approximately one-third of the annual flyway harvest. Harvest of snow geese has not tracked population growth.

Changes in the distribution of snow goose populations and harvest prompted concern in the early 1970s among southern states that lesser snow geese would abandon historical wintering areas. In addition, managers feared the consequences of increased concentration of these birds on midwestern refuges; disease, crop depredation and changes in recreational opportunity were cited as potential problems. These concerns were shared by the Central Flyway, and an ad hoc committee, with joint flyway representation, met during the early 1970s to discuss these issues and propose potential strategies for addressing them.

Interest in snow geese during the 1970s prompted an analysis of early snow goose banding. Dzubin et al. (1973) found significant increases between snow goose harvest and delays in migration; however, no firm conclusions could be made concerning reduced recreational opportunity in Gulf Coast states. Long-term nesting studies at La Perouse Bay (Cooke et al., n.d.) and an Arctic banding project also were initiated during this era. Much of the initial impetus and cooperative funding for breeding grounds work came from the Mississippi Flyway Council and Technical Section. With the exception of La Perouse studies, little snow goose research has continued on the breeding grounds into the 1980s. Populations have increased, and concerns for changes in distribution have largely been offset by greater numbers of snow geese. Because of problems with other waterfowl, snow geese have been relegated to a lower priority for research and management.

Canada Geese

Canada geese are distributed throughout the Mississippi Flyway and three primary populations of migrant Canada geese have been managed intensively. The Tennessee Valley Population (TVP or Southern James Bay Population) nests inland along the southern and western coasts of James Bay and on Akimiski Island. During migration and wintering periods they are affiliated with Ontario, eastern Michigan, Ohio, Indiana, eastern Kentucky and Tennessee, and Alabama. The Mississippi Valley Population (MVP) nests in the lowlands along the northern coast of James Bay and west of Hudson Bay in Ontario and migrates through Ontario, western Michigan and Wisconsin to wintering areas in Illinois, western Kentucky and Tennessee, and southeastern Missouri. The Eastern Prairie Population (EPP) nesting range is in northern Manitoba, west of Hudson Bay. Geese associated with this population migrate through Manitoba, Minnesota and Iowa to wintering areas in Missouri and Arkansas.

Giant Canada geese nest in all states and provinces in the Mississippi Flyway, and migration and wintering patterns vary greatly. Smaller races of Arctic-nesting Canada geese comprise the Tall Grass Prairie Population (TGPP). Numbers have increased in the western Mississippi Flyway during the last decade; however, affiliations with breeding and wintering areas are poorly defined.

Until recently, most management decisions involving Canada geese were based upon the status of the three primary migrant populations (MVP, EPP and TVP). Increases in numbers and distribution of Giant and TGPP Canada geese in the Mississippi Flyway will require increased consideration of these populations.

Numbers of Canada geese have increased dramatically during the last 20 years in the Mississippi Flyway (Table 1). Record numbers recorded during December 1989 (1,850,000) were three times the 1969 estimate of 589,000. While the trend in Canada goose numbers has been upwards, periods of depressed populations have occurred. The most dramatic increase has occurred in Giant Canada geese, with numbers ranging from 50,800 in 1969 to 272,000 by 1989. The MVP (population objective = 550,000) increased from 250,400 in 1981 to 1,097,900 in 1989. The peak population for the MVP during the 1970s (757,500) occurred in 1977. The EPP (population objective = 200,000) increased from 106,600 in 1969 to a peak of 270,200 in 1977. Populations generally declined after the mid-1970s to a low of 145,300 in 1981 and increased to a level of 324,900 by 1989. Populations of TVP Canada geese (population objective = 150,000) have been less variable, ranging from 106,900 in 1969 to 180,400 in 1977. The most substantial increase in the TVP occurred during the 1974–77 period, when populations increased from 101,000 to 180,400 birds.

Distribution of Canada geese in the Mississippi Flyway during fall and winter has changed over time. Historically, Canada geese migrated through northern states and often wintered along the lower Missouri and Mississippi river valleys. Some Canada geese went as far south as the marshes along the coast of the Gulf of Mexico. However, when flyway Canada goose numbers increased during the 1950s and 1960s, segments affiliated with southern states did not follow similar trends but continued to decline as they had in the 1940s. Several factors influenced this shift in distribution: improved habitat in the north created by increased production of corn and other grain (Reeves et al. 1968), water development projects (Simpson 1985), creation of state and federal goose management areas (Hankla and Rudolph 1967 Crider 1967) and differential harvest and survival rates (Raveling 1978). During mild winters of the 1980s, greater numbers of Canada geese remained north later in the fall and winter. Questions exist as to whether this is a short-term event or a long-term trend.

Disparity in Canada goose harvest among Mississippi Flyway states has caused great concern during the last 20 years. In 1962, 76 percent of the flyway Canada goose harvest (82,900) occurred in the states of Wisconsin, Michigan, Illinois and Missouri. Four states also accounted for the majority (71 percent) of the flyway harvest (394,200) in 1988; however, Minnesota replaced Missouri as a major harvest state. In Minnesota, an increase from 7 percent to 20 percent of the flyway harvest, a ten-fold increase in numbers harvested, occurred from 1962–88. Similar increases were recorded in Ohio and Kentucky; however, the combined harvest in these two states was only 5 percent of the flyway total.

Efforts employed to achieve more equitable distribution of Canada geese in the Mississippi Flyway have not been highly successful. Large numbers of Canada geese were trapped on midwestern concentration areas during the 1950s and 1960s and transported for release in southern states in hopes of restoring traditional migration and wintering patterns (Hankla 1968). In more recent years, population objectives have been increased in some areas to determine whether ''spillover'' to southern areas would result from larger numbers. Some efforts to change distribution have been counter-productive. Attempts during the 1970s to reduce Canada goose use of Horicon NWR and hasten southern migration resulted in increased dispersal, but survival rates declined (Rusch et al. 1985). While no sustained improvement in distribution has occurred, southern wintering populations have been higher during some recent years. Neckcollar studies conducted since the mid-1970s (Sullivan et al. 1989) should be of value in further defining Canada goose migration patterns, thus improving management of Canada geese among regions of the flyway.

The harvest of Canada geese in the Mississippi Flyway has generally tracked population trends. Harvest increased from 82,900 in 1962 to 425,800 in 1978 (Table 2). The record high harvest in 1978 occurred during a year of production failure, apparently exceeding the capacity of populations to recover in the short term. Declining populations (and harvests) during the late 1970s prompted restrictive regulations to reverse this trend. Numbers increased during the mid-1980s, and by 1989 population levels had exceeded those of the late 1970s.

Harvest control has been the key to the growth of Canada goose populations in the Mississippi Flyway. Techniques employed have included closed seasons, reduced season length, restrictive bag limits, and establishment of refuge areas. However, use of quotas to limit Canada goose harvests in concentration areas has been by far the most important management tool. Canada goose harvest quotas were first used in the Mississippi Flyway in Illinois in 1960 (Reeves et al. 1968). Since that time, most Mississippi Flyway states have established quota zones to control Canada goose harvests. Without these efforts by state and federal conservation agencies, Canada goose populations in the flyway would be much lower.

Specific information on population size, productivity and survival has been used to manage Canada goose populations in the Mississippi Flyway. Breeding ground investigations have been aimed toward collecting information on breeding biology, population affiliation and survival. On migration and wintering areas, research has been directed toward wintering ecology, land management for Canada geese, harvest control techniques, population affiliation and survival. Breeding ground research has been conducted largely through cooperative funding by state, provincial and federal agencies, while research away from breeding areas has often been conducted through individual state efforts. Studies of neckcollared geese are examples of flyway-wide cooperation. Research has been the basis upon which Canada goose management programs have been amended. Long-term monitoring of populations will continue to be essential for maintaining comprehensive and dynamic management programs.

Current and Future Management Challenges

Populations of ducks are severely depressed. However, geese associated with the Mississippi Flyway begin the final decade of this century in good numbers. In fact, goose populations in some regions exceed desirable levels. Habitat capabilities and human tolerance are being challenged. Because nesting habitat for these populations of geese is fairly stale, the fate of these resources is largely in the hands of managers in the United States and Canada.

White-fronted Geese

White-fronted geese in the Mississippi Flyway will likely continue to migrate through the western Mississippi Flyway and winter in Louisiana. Management should be coordinated with Central Flyway states. Appropriate states should continue participation in coordinated white-fronted goose population surveys and should consider the habitat needs during fall migration and spring staging. White-fronted geese should be considered a high priority for the Arctic Goose Joint Venture of the North American Waterfowl Management Plan.

Lesser Snow Geese

Resource managers should not become complacent about the status of snow geese in the 1990s, despite increasing numbers. Following elevated interest in lesser snow geese during the late 1960s and early 1970s, little attention has been focused on this species. Funding for nesting ground studies has been reduced substantially, and little migration and wintering ground research has continued. The prevailing attitude is that lesser snow geese exist in good numbers in the Mississippi Flyway, and few problems are apparent. Therefore, funding for research or other management needs is low priority. This attitude has been clearly illustrated as framework dates, season lengths and bag limits have been liberalized without information other than winter population estimates upon which to base these decisions.

Lesser snow goose distribution in the Mississippi Flyway, including the breeding grounds, continues to be very dynamic. During the drought years of the late 1980s, lesser snow geese substantially reduced use of some midwestern refuges and increased use of other regions, particularly in northeastern Louisiana, eastern Arkansas and southern Missouri. On the breeding grounds, evidence of snow geese impacting their nesting habitat has not been studied adequately. Without efforts to study these phenomena, the reasons for the changes and their impacts will be mostly speculative. This approach may be acceptable as long as populations are high, but if numbers decline, there will be little information from which to begin investigations into the factors involved.

Canada Geese

Canada geese are a valuable resource in the Mississippi Flyway. During the 1988–89 hunting season, Canada geese were second only to mallards in the number of waterfowl harvested. The importance of Canada geese in the flyway will continue to be magnified as long as duck populations remain low and the current levels of Canada geese can be maintained.

During the 1990s, significant changes in management strategies will be required to address problems and opportunities associated with Canada geese in the Mississippi Flyway:

1. Nesting ground surveys should be refined, standardized and expanded to include all major populations including giant and TGPP Canada geese. These surveys should be the primary methods used to define populations, assess their status and predict annual fall flights.
2. Periodic fall and winter surveys should continue to be used as an index to distribution of various goose stocks.
3. Leg-banding historically has been used to monitor survival and distribution of Canada geese. Neckcollaring, which has been conducted in addition to banding since the mid-1970s, provides more reliable and timely information for many management decisions. In addition, data can be collected to reflect distribution outside the hunting season or in regions where hunting is not allowed. Neckcollar icing, however, continues to be perceived as a primary deterrent to use of neckcollars (Zicus 1983). Efforts to develop alternative collar materials to reduce or eliminate icing problems should continue. A strategy should be considered for operational employment of neckcollaring of Canada geese in the Mississippi Flyway.
4. Inequitable distribution of Canada geese will continue to be a problem facing waterfowl managers in the Mississippi Flyway. States hosting increasing populations must accept responsibility for providing seasonal goose requirements and for controlling harvests. In addition, states with lower populations must gain an increased appreciation for problems associated with escalating numbers in other regions and support harvest strategies that will keep levels within habitat and landowner tolerances.
5. Migrant Canada geese comprise only one component of Mississippi Flyway Canada goose populations. Giant Canada geese represent a rapidly increasing segment and numbers of small Canadas are increasing in some regions as well. Canada goose management has become more complex, with increased mixing of populations on migration and wintering grounds. It is unlikely that we can

continue to establish management objectives that are based primarily upon information for migrant Interior Canada geese alone. Consideration should be given to development of management objectives that include all populations represented within regions of the flyway. However, this will increase, not reduce, the need for population, production and survival data for each goose component.

6. Giant Canada geese have reached nuisance proportions in some areas of the flyway, and special hunting seasons have been prescribed in some areas to reduce populations. These hunts should be continued and expanded to other areas, but increased hunting opportunity for giant Canada geese should not be limited to local breeding populations. Like other waterfowl, giant Canada geese should be viewed as a shared resource. Opportunity for controlling increasing giant Canada goose populations from northern states may also occur on the wintering grounds. Also, the increased recreational value of these hunting programs should be emphasized as well as the need to address nuisance problems. Better knowledge of the migration patterns and wintering areas for giant Canada geese is needed.
7. Too much emphasis has been placed on "traditional" distribution of Canada goose populations and harvest. It is doubtful that traditional patterns can be an effective basis upon which to justify management of these dynamic resources. Goose managers must consider the way in which geese have responded to the changing habitat base and harvest strategies.
8. Canada goose management strategies need to reflect the most current information available. Data concerning seasonal distribution and survival, from neckcollar and radio transmitter studies, and age-related productivity research is information that has been collected during the 1980s that has yet to be completely incorporated into population management plans.
9. Methods used to monitor and manage Canada geese differ among the groups responsible for the various populations. Managers would benefit, however, from an increased interchange of this information. The international Canada goose symposium, scheduled for spring 1991, will provide a timely forum for the exchange of these data.
10. Populations of Canada geese are currently at record levels. Goose managers should complete or amend population management plans while populations are high. Consensus is more difficult to obtain when populations are low and restrictive regulations are most needed.

Most management plans for geese include objectives for average populations and average harvest levels. Yet problems faced by goose managers have involved extreme rather than average numbers of geese. Historically, low populations and harvest were the primary concern. The challenge for the 1990s will be to address higher population levels, without the detrimental impacts that occurred during the late 1970s. A balance must be achieved among the desires for sustained high harvest levels, the limits of habitat capacity and landowner tolerance.

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Goose Management in the '90s: A Central Flyway Perspective

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Introduction

Since its inception, the Central Flyway (CF) has vigorously pursued the wise stewardship of our waterfowl resources. Presently, most populations of geese in the CF are at all time highs. Along with the successes of the CF goose management efforts, there have been numerous problems and challenges, many of which persist today. To improve the stewardship of our geese in the face of increasing and changing demands of society, we must successfully address these problems. This paper will provide a brief account of the status of CF goose populations, major problems we face, and recommendations for future management.

During the early 1980s, the Central Flyway Council (Council) adopted management plans for nine populations of geese. These included: western central flyway (WCF) snow and Ross' geese (*Chen caerulescens caerulescens* and *C. rossi*); mid-continent (M-C) snow Geese (*C. c. caerulescens*); tall grass prairie (TGP) Canada geese (*Branta canadensis parvipes* and *B. c. hutchinsii*); western prairie (WP) Canada geese (*B. c. interior*, and some *B. c. maxima*); great plains (GP) Canada geese (*B. c. maxima* and others); short grass prairie (SGP) Canada geese (*B. c. parvipes* and *B. c. hutchinsii*); hi-line (HL) Canada geese (*B. c. moffitti* and *B. c. maxima*); western mid-continent (WM-C) white-fronted geese (*Anser albifrons frontalis*); and eastern mid-continent (EM-C) white-fronted geese (*A. a. frontalis*). Plans for GP Canada geese and WP Canada geese have since been combined into one.

A common goal of CF goose management plans is maximum recreational opportunities consistent with the welfare of the various populations, international treaties, and habitat constraints. Objectives include: protection of adequate habitat; preservation of historical migration and wintering traditions; maintenance of population levels which satisfy user groups; and maximum nonconsumptive use consistent with local management programs.

Status

Goose populations included in seven of these plans exhibit stable or increasing population trends. The WM-C white-fronted goose population shows a declining trend. Table 1 presents a summary for status, trend and objective for each population.

Table 1. Status and objectives (in thousands) of major Central Flyway goose populations (Ladd 1989).

Population	Winter population index 1985–1988	Recent trend	Winter index objective
Canada Goose			
Western prairie/great plains	260	Increasing	275–300
Tall grass prairie	217	Stable	250
Short grass prairie	202	Increasing	150
Hi-line	101	Increasing	80
Snow and Ross' Goose			
Mid-continent	1,768	Increasing	1,000[a]
Western central flyway	70	Increasing	110
White-Fronted Goose			
Eastern mid-continent	86	Increasing	50–80
Western mid-continent	102[b]	Decreasing	200–300[b]

[a]Breeding geese
[b]Spring Index

Harvest

The CF normally ranks second among the four flyways in the number of wintering geese and their harvest. Total goose harvest for the CF has grown from an estimated 182,000 in 1955 (BSFW 1971) to an average of about 558,000 for the years 1981–85 (U.S. Department of the Interior and Canadian Wildlife Service 1986). This growth reflects the expanding importance of geese to our flyway. Since 1985 the harvest of Canada, snow and white-fronted geese has declined in the U.S., possibly due in part to fewer hunters afield because of low duck populations. Table 2 contains a summary of geese harvested in the CF since 1962.

The states and the Council have initiated numerous regulatory measures to achieve harvest, distribution and population objectives. Many states have limited seasons within zones to protect restoration Canada geese. Restrictive regulations, such as a daily bag of one Canada or one white-fronted goose, were established to allow TGP Canada and white-fronted geese to increase. Early closures were initiated in Kansas and Nebraska to limit the harvest of restoration (GP Canada) geese from the Dakotas and Nebraska. Since 1980, regulations designed to limit the harvest of early migrating TGP Canada geese in the Dakotas have been in effect to maintain traditional distribution of harvest to mid-latitude and southern states of the CF.

Table 2. Estimates of regular-season average harvest of Canada, snow/blue and mid-continent white-fronted geese in the U.S. portion of the Central Flyway (Ladd 1989)[a].

Years	Canada goose	Snow/blue goose	White-fronted goose
'62–65	102,900	107,000	22,900
'66–70	147,900	191,800	27,900
'71–75	159,300	235,600	42,600
'76–80	181,000	268,400	51,200
'81–85	235,800	257,400	65,100
'86–88	203,600	175,400	42,900

[a]Number rounded to the nearest 100.

Problems and Needs

As goose populations expand and duck populations remain below desired levels, interest and participation in goose hunting will almost certainly increase in the CF. At the same time, the ability to manage specific goose populations and their harvests is becoming more complex. Most problems relate to the basic needs for managing a hunted population—difficulty in monitoring the size, status and distribution of a population, and only limited ability to estimate the harvest taken from a population and the effects of that harvest. Some of the major needs already identified in our goose management plans include: (1) better delineation of breeding, migration and wintering grounds; (2) improved methods of monitoring population status and trend; (3) adequate and cost-effective means to estimate harvests; (4) better understanding of diseases and methods to minimize disease losses; (5) harvest regulations which achieve predictable harvest objectives; (6) acceptable strategies to minimize autumn migration delays and occurrence of undesirable migration and wintering patterns; and (7) adequate survival rate estimates.

The status of mid-continent white-fronted geese, heretofore considered and managed as two separate and distinct population segments, is perhaps the most serious question concerning geese in this flyway. Based on recent limited banding and neck-collaring information, the earlier distinction between eastern and western segments appears questionable (Bromley, Unpubl. data; 1990). If the two segments are distinct, survey data suggest that the western segment has declined dramatically in the past decade and is well below the population objective identified in the management plan. At present, limited data are available to estimate and monitor survival rates, changes in distribution, or even population size and trends. We recognize an urgent need to better delineate and monitor whitefront populations, assess productivity, and estimate harvests.

The mixing of three populations of Canada geese in the eastern tier of states (North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and east Texas) during migration and winter periods seriously hampers our ability to manage and monitor these populations. WP and GP Canadas, both comprised of "large" birds, mix with the smaller TGP geese. Thus our ability to distinguish these separate populations in order to monitor their respective population trends is severely limited, including during the traditional mid-December survey period. Largely because of this mixing, management plans for the WP and GP Canadas were recently combined. Despite requirements contained in the combined plan to monitor GP and WP Canadas on their respective breeding grounds, these surveys have not been conducted adequately.

The status of TGP Canada geese is also questionable, again due primarily to mixing with WP and GP Canada geese during winter surveys. Large fluctuations in population estimates of TGP and large Canada geese in east tier states may be at least partially due to difficulties in delineating large from small birds during surveys. Management of TGP Canada geese is further complicated by their mixing with SGP Canada geese in some mid-CF areas. Also, in recent years significant numbers of small Canada geese believed to be TGP birds have been observed in the extreme western Mississippi Flyway (MF). Information on the extent and effects of these population shifts will be required to manage these geese.

The distribution controversy has subsided somewhat since the early 1970s, when "short-stopping" occurrences were a major concern. However, changing agricultural practices linked with the presence of impoundments with open water throughout the winter have increased the proportion of Canada geese wintering north of their historical winter ranges. Some now winter as far north as North Dakota in some years. Establishment of resident GP Canada goose flocks in mid- and northern-latitude states seem to have further contributed to the problems of delayed migration and harvest management. Regulatory efforts, such as an extended season along the Missouri River in South Dakota, have had limited success in reversing these problem trends.

Both snow goose populations in the CF have increased over the past decade. The growing population of WCF snow and Ross' geese has resulted in serious depredation in some New Mexico wintering areas. Extended hunting season frameworks and larger bag and possession limits have done little to slow the growth pattern of this population.

As early as 1972, concern was expressed about long-term damage to breeding habitat by mid-continent snow geese in some of their breeding colonies. In recent years, this concern has grown (Cooke 1988) as the population increased to nearly 2 million birds, according to mid-December surveys. Harvest regulations are already liberal, and further liberalization of standard regulations is likely to have little effect. In fact, harvests in both the CF and MF have recently declined while the population has been increasing.

In the western tier states (Montana, Wyoming, Colorado, New Mexico, and west Texas), problems similar to, but not as severe as those of the eastern tier exist with SGP and HL Canada geese. Due to inadequate banding in recent years, information is weak on survival and harvest rates as well as shifts in distribution. Although these two populations are comprised of ''small'' and ''large'' geese respectively, they mix on staging, migration and wintering areas, increasing the complexity of monitoring individual population sizes and trends. Similarly, harvest estimates of these two populations are poor due to inadequate harvest survey methods and small sample sizes of goose tails from the Federal Waterfowl parts Collection Survey. As in the eastern tier states, delayed migrations and more birds wintering north of traditional areas are of concern for SGP and HL Canada goose populations. Also, problems with resident and migrant geese in some urban areas are becoming more serious and frustrating.

As the quality and quantity of habitat decreases, goose populations become concentrated and the risk of catastrophic losses to disease increases. The Rainwater Basins of Nebraska are a prime example of a potentially critical disease situation. Virtually all white-fronted geese common to the CF stage here for several weeks each spring, along with large segments of the TGP and mid-continent snow goose populations. In some years, large numbers of geese and other waterfowl have died from disease outbreaks, primarily avian cholera.

Recommendations

We are rapidly approaching a crossroads in goose management. With more frequent changes in distribution and mixing of populations occurring and an increasing interest in goose hunting, existing databases and monitoring programs need strengthening in order to improve management of geese into the 1990s. The greatest challenge faced by state, provincial and federal waterfowl managers is to provide additional resources needed to obtain data necessary to manage individual populations where they now exist. Improved databases and more precise management practices are required if we are to maintain population distinctions.

In order to continue the improvement of goose management techniques into the 1990s we recommend the following:

1. Establish high priority banding programs on the breeding and/or staging grounds of respective populations, where appropriate, to adequately estimate and monitor survival and harvest rates and to assist in delineation of ranges of each population. The role and value of winter banding, alone or in connection with summer banding, have to be assessed and programs implemented where needed.
2. Implement surveys, where feasible, to assess the status and/or productivity of specific populations on their breeding grounds.
3. Improve our ability to estimate harvests of individual populations and/or subspecies, at the state, provincial and, ideally, at the county level.
4. Strategies must be developed for maintaining, increasing or decreasing specific populations of geese according to their status and objective levels, including habitat-related alterations and/or hunting regulations.
5. Improve our ability to survey and monitor specific goose populations at appropriate times in the annual cycle.
6. Initiate experimental management programs and regulations designed to reduce undesirable concentrations of geese and redistribute them to other areas.
7. Improve our understanding of the effects of hunter harvest, both sport and subsistence, on goose populations.
8. Where appropriate, continue and/or initiate collaring or other visual marking efforts designed to increase our knowledge on distribution and other factors relating to geese throughout the year.
9. Establish a centralized entity, such as additional staffing at the Fish and Wildlife Service's Bird Banding Lab, to improve coordination of various collaring studies and serve as a repository for the data.
10. Increase research efforts on diseases that affect geese and management actions that can be undertaken to minimize losses.
11. Expand research on snow geese to better understand population dynamics and the effects of the large and increasing populations on their habitats and other waterfowl.
12. Increase efforts to provide for and encourage non-consumptive uses of geese.
13. Continue efforts to better understand the needs of northern subsistence users and bring their goose harvest into a legal management framework.
14. Substantial numbers of CF geese winter in Mexico. We need to improve our knowledge of the numbers involved and the harvest they sustain, as well as encourage greater involvement of the Mexican federal and state governments in the management of these birds, and protection of their habitats.
15. Increase efforts to educate hunters about the biology of their quarry as well as the ethics of hunting and work towards elimination of illegal conduct by hunters.
16. Finally, there is a need for an international scientific body to evaluate, coordinate and recommend priorities on the numerous research and management needs and projects which transect flyway and international boundaries. Funds will always be in short supply and it is imperative that we allocate them in the most productive way possible to the highest priority activities. We recommend that the Arctic Goose Joint Venture, called for in the North American Waterfowl Management

Plan, be fully activated and play a leadership role in accomplishing this interflyway and international coordination.

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Management of Pacific Flyway Geese: An Exercise in Complexity and Frustration

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Introduction

The Pacific Flyway stretches from the Arctic north slope of Alaska and islands in the high Arctic of Canada and the USSR to the Pacific waters of Mexico. These climatic conditions ultimately dictate the distribution of Pacific Flyway goose populations, as primary determinants for nesting and wintering sites. However, several other factors are integral to the flyway's goose management scheme. Factors such as the contrasting southern California lifestyle and the lifestyles and traditions of native cultures of rural Alaska play major roles in the management direction for geese in the flyway.

From its inception, waterfowl management in the Pacific Flyway was driven by a desire to understand the resource better. Prompted by a decline in the Great Basin's Canada goose (*Branta canadensis moffitti*) population, the Great Basin Canada Goose Subcommittee was formed in 1958. This subcommittee was comprised of representatives from the states of Arizona, California, Colorado, Idaho, Montana, Nevada, Utah and Wyoming, and the province of Alberta and a representative from the U.S. Fish and Wildlife Service (FWS). The subcommittee functioned to identify data needs and to initiate cooperative waterfowl projects. Major banding and collaring efforts conducted by the states and Alberta resulted in delineation of population ranges and knowledge of the composition of molting flocks. Annual breeding pair and production surveys were conducted for each production area, establishing a long-term data base for use in monitoring population changes. This early effort demonstrated that management success could in fact be achieved over the vast range of Pacific Flyway Waterfowl populations.

Current Status

The Pacific Flyway's goose population is comprised of 16 species, subspecies and local sub-populations of geese: western arctic snow geese (*Chen caerulescens caerulescens*); Wrangel Island snow geese (*C.c. caerulescens*); central arctic Ross' geese (*Chen rossi*); Pacific population white-fronted geese (*Anser albifrons frontalis*); Tule geese (*A.a. gambelli*); Pacific population of western Canada geese (*Branta canadensis moffitti*); Rocky Mountain population of western Canada geese (*B.c. moffitti*); emperor geese (*Chen canagica*); cackling Canada geese (*B.c. minima*); dusky Canada geese (*B.c. occidentalis*); lesser Canada geese (*B.c. parvipes*); Taverners Canada geese (*B.c. taverneri*); Vancouver Canada geese (*B.c. fulva*); Aleutian Canada geese (*B.c. leucopareia*); and Pacific brant, which are composed of black brant (*Branta bernicla nigricans*) and a small but regular contingent of Atlantic brant (*Branta bernicla bernicla*).

In the late 1970s the Fish and Wildlife Service and the Pacific Flyway Council provided the impetus to develop management plans for various goose populations. Together, these organizations consolidated the latest information in a format which has provided management direction for attaining the Flyway's population objectives. Various subcommittees formed in the 1970s continue to meet on a biannual basis to review new research and to make recommendations to the Council. Management plans or recovery plans have been adopted by the Council for eight goose populations and draft plans have been developed and are functioning for the remaining populations. Each plan has established population objectives (Table 1), identifies and discusses problems associated with the population and provides management recommendations to address identified needs.

While we acknowledge the large number of goose species in the flyway, the opportunity to manage each of these species individually does not exist. Currently, all white geese are managed as a group, and the Taverners and lesser Canada geese are included in one management plan.

Our knowledge of the various goose populations continues to expand. The discovery of the Tule goose nesting grounds and subsequent population estimates occurred as recently as 1980 (Timm et al. 1982). Many, though not all of the questions which have confronted managers over the years have been answered. At the same time, many of those answers have posed *new* questions.

Given the time allotted to this paper, the status of each of the populations will not be detailed. However, the examples which have been chosen provide a window to goose management in the flyway.

White Geese

Included in the white geese category are the Ross' and two populations of snow geese: western Arctic and Wrangel Island. The Wrangel Island snow geese migrate from eastern Siberia to the Pacific Flyway to winter from the Skagit Bay of Washington to the Central Valley of California where they later intermingle with the western Arctic population. Ross' geese from the central Arctic follow a migration path similar to western Arctic snow geese wintering in California's Central Valley. Although the numbers of wintering white geese have remained stable, survey infor-

Table 1. Population objectives and most recent indices for Pacific Flyway geese.

Species	Population objective	Status
Dusky	20,000	11,800
Cackler	250,000	76,800
White-front/tule	300,000	225,700
Emperor	150,000	46,000
Western Canada		
RMP	50,000	73,700
Pacific	4,700 (breeding)	7,200
Pacific Brant	185,000	146,000

mation indicates that species composition has been changing. Marking studies (Silveria 1989) indicate that the proportion of Ross' geese in the wintering population is increasing.

Hunting seasons have been conservative with bag and possession limits of three and six, respectively, with no species-specific bags for now and Ross geese since 1979.

Western Canada Goose

The western Canada goose population includes both the Rocky Mountain (RM) population and the Pacific (P) population. These populations are managed independently because of differences in geographic distribution and migration habits (Krohn and Bizeau 1980).

The largest population is the RM, which totalled nearly 74,000 birds at the time of the most recent winter index. Although wintering flocks are concentrated in the southeastern Idaho and southern California portions of the flyway, geese may be found in all portions of the flyway during mild winters. The RM population has responded to habitat development and enhancement throughout its range. Intensive efforts at transplanting birds into unoccupied habitats in the province of Alberta and in the states have paid dividends. The population's geographic range has been expanded, lending an important measure of stability to annual production rates. Management efforts are now directed toward equitable harvest among flyway states. Hunting seasons extend up to 93 days with bag and possession limits of either two and four or three and six, respectively.

Dusky Canada Goose

The dusky Canada goose population is below the objective established in the plan and offers a typical example of just how complex the Flyway's management program can be. Habitat changes associated with the uplifting of the Copper River Delta after the 1964 ''Good Friday Earthquake'' now support a full suite of avian and mammalian predators that have greatly reduced production (Cornely et al. 1985). Although this was not unexpected, the sudden drop from 23,000 to 17,000 geese in 1982 resulted in shorter hunting seasons the following year.

Factors surrounding the management of the dusky goose population have involved not only lack of recruitment and high hunting mortality in the past, but growing use of wintering areas by lessers, cacklers and western Canadas. Manipulation of the goose harvest to protect duskys and cacklers has been through shortened seasons, reduced bag limits and emergency closures. Ironically, total goose numbers are near all-time highs in the Oregon and Washington wintering areas. This large congregation of geese has resulted in confusion among sportsmen. Efforts to address the large numbers of geese include intensive hunter education programs designed to direct harvest toward the less vulnerable but more abundant species such as the Taverners. To their credit, the states of Oregon and Washington have implemented a mandatory hunter education certification program to increase the potential for harvesting the more plentiful races under a quota system.

Cackling Canada Goose

The cackling Canada goose nests on the Yukon-Kuskokwim (Y-K) Delta of western central Alaska and winters in the Central Valley of California. This population has become an issue because of its dramatic decline in numbers. The decline from 400,000 in the 1960s to only 25,000 in the mid-1980s has been attributed to excessive sport and subsistence harvests (Raveling 1984).

Harvest restrictions on cackling Canada geese began in 1975 with the implementation of large area closures in the heart of the primary waterfowl hunting areas of California. While the initial closure was intended to benefit the Aleutian goose, benefits to the cacklers occurred simultaneously. Additional harvest restrictions were instituted in California in 1979. In 1982 Alaska initiated hunting restrictions in fall staging areas. Despite these restrictions, cackling Canadas continued to decline and a total closure was instituted in 1984.

While recreational harvests were being reduced through various restrictive measures, efforts were also underway to reduce subsistence hunting taking place on the Y-K Delta. The 1984 Hooper Bay Agreement and the Yukon-Kuskokwim Delta Goose Management Plan (YKDGMP) were implemented to enhance protection of cacklers, brant, whitefronts and emperors (Pamplin 1986). Substantial reductions in the spring harvest of both eggs and geese were accomplished. Continued broad support of cooperative harvest restrictions and other conservation programs have yielded a three-fold increase in the cackler population.

Aleutian Canada Goose

The endangered Aleutian goose, while not a hunted species, is an important ingredient in the goose management scenario. Strategies for recovery of the population have important consequences for the management of other goose species which use the same habitats. Efforts have been focused on the re-establishment of breeding flocks of Aleutian Canadas on three islands which were former nesting colonies. While initial attempts were less successful than anticipated, progress is being made. Implementation of area closures on key Aleutian wintering habitat in California in the 1970s, combined with additional cackler restrictions, have resulted in population increases. The spring index has risen from the low of 790 in 1975 to more than 6,400 this past winter. As a result, consideration is being given to downlisting Aleutians from endangered to threatened (McNab and Springer 1990).

While these examples of management by regulation may seem excessive, they are only one part of the management program. Extraordinary efforts have also been made in the habitat arena. Creation of special refuges and goose management areas to protect staging and feeding areas have also been accomplished. California's $40 million bond program to acquire wetlands for wintering waterfowl is unprecedented but unheralded. National conservation organizations, hunting groups and native organizations have all been active participants in preserving habitat essential to the welfare of Pacific Flyway goose populations.

The Future

Goose management in the Pacific Flyway will continue to be a complicated challenge. Those populations, which experienced dramatic declines during the 1970s, are now increasing in response to restrictive management strategies. Cacklers, duskys, whitefronts and Aleutians are still below population objectives and will continue to receive special attention. A level of frustration accompanies the search for management solutions for manager and sportsmen alike. The intermingling of various goose populations hampers the manager's ability to effectively monitor populations on the wintering grounds. Special zones, closures and identification problems continue to frustrate the sportsman. While certain populations certainly warrant protection, the Taverners, Pacific and Rocky Mountain Canada goose populations continue to grow to the extent that depredation of agricultural crops has become a problem in many areas.

One obvious approach to the complex management of various subspecies of geese is simply to manage them all as a single conglomerate population, (i.e., all white-cheeked geese). While this approach has some validity, it also has inherent flaws. A ''single population'' management program was in practice 20 years ago because we lacked the knowledge to manage at a more refined level. There is little doubt that this generic management approach contributed to the decline of certain species. So, while single population management may appear on the surface to be the easiest route, the resource and those who enjoy it would be the losers. Our ability to manage these populations in the 1990s will depend upon our ability to gain adequate knowledge and understanding of the changes which are taking place around us. Many goose populations nest in remote areas of Alaska, Yukon and Northwest Territories. It's critical that accurate surveys be developed to yield reliable population data for management purposes.

Our current population objectives are based upon historical records and population estimates and may need to be adjusted to reflect our most current knowledge of population dynamics as well as significant habitat changes.

Our survey and research needs are endless. As with any agency or bureaucracy, priorities will influence funding which will in turn determine what gains can be made for Pacific Flyway geese in the 1990s. A foundation has been laid by programs such as the YKDGMP and establishment of communication channels with Mexico and the Soviet Union. It will be greatly enhanced by development of the Arctic Goose Joint Venture. Results do not come easily or quickly. Only through continued dedication and understanding in the face of frustration will we make strides in goose management in the Pacific Flyway. The Pacific Flyway Council is committed to meeting that challenge in the 1990s.

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Goose Management in Canada

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Growth and Mixing of Goose Populations

The substantial growth in the size of most goose populations during the 20th century, and especially in the last 50 years, has increased encounters between their sub-units, at all times of year, at the same time as it has produced larger aggregates at many refuges and other roosting, feeding and moulting sites. One question of importance to managers is whether the ''metropolitanization'' of geese is itself contributing to population limitation. It seems to be true in general that increases in total stock size do not continue to be accompanied by increases in the numbers of successful parents, though no one has yet demonstrated how the levelling-off of breeding stocks is brought about. It may not be frivolous to suggest that a rising standard of living may reduce effective fertility in geese.

Harold Hanson has demonstrated the extraordinary extent to which Canada Geese have formed closed population units, with resulting differences in the appearance of members of those units. The idea that there may be more than 130 stocks of Canada Geese, most of them recognizable only by specialists and only in the hand, makes conservation agencies uncomfortable because it raises awkward questions about how to deal with that particular kind of biological diversity. Is it proper to take expensive steps to ensure the well-being of the Aleutian Canada Goose while ignoring the claims of the geese of Akimiski or Anticosti islands?

The proliferation of Canada Geese may well mean that it is already too late to ''save'' most of their island forms, because their reproductive isolation has been reduced as they are obliged to share wintering and staging areas with geese from other stocks. The extent to which such ''swamping'' has already occurred is not known and cannot be examined retrospectively because records of past field observations of unmarked geese are equivocal if, as Hanson has argued, up to six subspecies may be present in a single staging flock. It would be difficult and expensive to study mixing by means of visible-marking projects. Whether it may be possible to do so by means of blood- or tissue-sampling should be explored.

Mixing and muddling of stocks has also resulted from many of the (re-) introduction projects that have been carried out in recent years, from British Columbia to the Atlantic coast. These may have had results analogous to the widespread use of mallard rearing and release projects. Many years ago Konrad Lorenz suggested that there were no 'wild' mallard left in Europe for that reason. The survivors of goose release projects have shown their ability to cope with a particular set of man-made stresses. Their mixing with other stocks may nevertheless have resulted in reduced fertility and survival among the population at large. This may not be a matter of concern to the program managers who seen an abundance of geese where there were few or none, although those managers soon become aware of local ''damage'' problems.

It seems unlikely that consensus could ever be reached across North America on a strategy for the management of Canada geese. In Canada we are increasingly conscious of the limitations in managing such arbitrary aggregates as the tallgrass prairie population, which includes a mixture of many breeding groups. We believe it can be helpful to use breeding units, rather than wintering ones, to monitor the fortunes of most stocks of Canada geese; but we recognize that wintering counts will also be required.

An interesting long-term phenomenon among the Arctic-breeding snow geese is the growing overlap of the breeding ranges of lesser snow geese and Ross's geese in the central Arctic and those of lesser and greater snow geese in Foxe Basin and on western Baffin Island. Inter-specific hybrids among geese kept in captivity are often fertile. Many mixed pairs of snows and Ross's accompanied by offspring have been seen in the wild. How long might it be before we can no longer distinguish easily between these two species? The differences between lesser and greater snows are already small. Will they almalgamate in an American melting pot, or will they retain their ethnic identity, Canadian-style?

Geese, Agriculture and Climate Change

Geese have been among the greatest beneficiaries of modern agriculture, in Europe as well as in North America. Large fields, heavy use of fertilizers, improved strains of grasses, cereals and corn and, in some cases, fall feeding has all helped to make life easier for them away from their northern breeding grounds. Even the brant is profiting from better grasses on golf courses.

This means that, more than ever before, the future of geese is tied to the future of farming. Farming itself is in a period of uncertainty and change, as North America loses its former dominance in the international cereals markets and internal competition increases.

The recent severe and prolonged drought in the prairies, which has been so bad for ducks, reminds us that weather affects waterfowl, both directly and indirectly. The use of golf courses by Atlantic brant began in the hard winter of 1976–77, when more than half the brant starved to death.

The effects of cold, late springs in reducing the breeding success of Arctic-nesting geese have been known for a long time; 1972 was a year in which geese in nearly all parts of the Arctic gave up trying. The recent warming of the Arctic has so far been confined to the winter. Warmer winters may speed the breaking-up of ice and melting of snow in spring, to the advantage of geese, even if the summers do not grow markedly warmer. Their most important effect seems likely to be through the melting of upper layers of permafrost, leading to changes in the soil structure underlying the wet meadows that are the most important feeding areas for geese and other northern birds. How far, and above all, how fast those changes may come about cannot yet be predicted. There are likely to be substantial losses of sedge meadows in the short term. But over centuries, rather than decades, the results could prove beneficial.

Highlights of Studies Planned for 1990

In 1990, the Canadian Wildlife Service (CWS) will begin an expanded program of studies on Arctic nesting geese. In a sense these will be the first-step projects of the Arctic Goose Joint Venture, which will start this year because the Canadian federal government has provided its share of the increased funding that is needed.

In the duck habitat joint ventures, we can make little progress without the support and active involvement of the landowner. We will find the same is true of the Arctic Goose Joint Venture, where the role of the landowner in several major goose breeding areas will be played by Canada's native people.

There are four major native land claim areas north of 60 degrees, which are expected to establish a strong native role in determining what is done with the land. It will be necessary for us to have these people's support for any Arctic goose work we wish to undertake. In addition, the claim agreements have established a significant role for native people in the cooperative management of wildlife, including harvest. For example, the Inuvialuit Final Agreement, which covers such important goose areas as the Mackenzie Delta and Banks Island, establishes a wildlife management advisory council. Half of its members represent the Inuvialuit. The council determines the allowable harvest in the claim area and makes recommendations to the appropriate minister of the crown. For migratory species, the Inuvialuit agreement specifies that Canada will endeavor to establish cooperative management agreements and arrangements with other countries, including safe harvest levels in each jurisdiction, joint research objectives and control of access to wildlife. In some ways, the wildlife management advisory councils will be analogous to flyway councils.

South of the Inuvialuit area in the Yukon is the Council of Yukon Indians' claim, which makes up most of that Territory. The remainder of the North West Territories is divided between the claims of the Dene Nation and the Metis Association in the southwest, and the Tungavik Federation of Nunavut, the vast eastern portion of the Territory, which includes most of the key goose breeding habitat. In each of these areas we expect that cooperative wildlife management boards will become our key forums for wildlife management.

The most pressing needs for new Arctic goose work are well known. In the embryonic stages of the Arctic Goose Joint Venture these were discussed among CWS, the U.S. Fish and Wildlife Service, and states and provinces in 1986. The joint venture will eventually provide the means and direction for such work.

Much of our concern for goose population delineation is centered around the Queen Maud Migratory Bird Sanctuary. This is the area where the division between eastern and western mid-continent white-fronts is supposed to lie. It is the zone of overlap between tallgrass prairie and shortgrass prairie Canada geese. It is the center of Ross's goose and the central Arctic lesser snow goose breeding ranges. To complete the picture, there are both Atlantic and Pacific brant in the area.

Among the CWS proposals for work in the Queen Maud Gulf area is the construction of a small camp on Karrak Lake, as a base for long-term studies on Ross's geese and lesser snow geese. It also will improve access to the central and eastern parts of the sanctuary, and so support work on tallgrass prairie Canada geese. Other proposed studies include surveys, banding, and habitat studies.

As part of the Canada/U.S.S.R. agreement for exchange of information on snow geese, CWS plans to assist in developing an aerial survey of the Wrangel Island goose colony. Wrangel Island has the last remaining large colony of snow geese breeding in the Soviet Union, and, as such, has special significance for that country. It is a colony with a troubling history of fluctuating size, having dropped to about 45,000 in 1975. The breeding ground survey will complement surveys in the Fraser and Skagit river wintering grounds, and continued observations of neck collars.

Dark geese are less obliging as research objects than white ones. Not only their cryptic coloring, but also their dispersed breeding habits make this so. While goose populations generally prosper, there is uncertainty bout the stocks of some dark geese. We are unable to delineate the supposed western and eastern components of mid-continent white-fronted geese, and we lack sufficient banding data for tallgrass prairie and shortgrass prairie Canada geese. Foremost among the proposed studies will be a coordinated attempt to mark the white-fronted goose across its entire Canadian breeding range. A similar project in Alaska will complement this broad-based sampling of mid-continent white-fronts that will help determine whether the western and eastern breeding birds can or should be managed as two units. Canada goose banding in the central and eastern arctic is proposed as well. We are looking to the Arctic Goose Joint Venture to ensure that this major undertaking is coordinated efficiently.

Jim Hines of CWS has worked in partnership with the Inuvialuit to show that population surveys of western mid-continent white-fronts and Canada geese breeding near the MacKenzie coast are feasible. They will be continuing these surveys in 1990.

As populations of geese increase, so does the stress that is caused to their habitat. For the geese this can have health effects, caused by poor nutrition or disease, or image effects, caused by their over-enthusiastic use of agricultural crops. Studies are being considered at three highly populated snow goose colonies (Queen Maud Gulf, West Hudson Bay, and Bylot Island) and in the Fraser River and the St. Lawrence River, where snow geese are running foul of farmers.

Canadian Geographic magazine has just reported on the 15-year plan in the Province of Quebec to complete the James and Hudson bay hydro power projects. The statistics on the size of this undertaking are impressive. About 20 rivers draining 350,000 square kilometers would be affected. The total area of reservoirs to be created would be larger than Lake Ontario. Within the project area water levels would change dramatically, with some reservoirs subject to an annual variation as high as 20 meters.

Two studies are planned to establish how the hydro projects might affect geese. One is to determine the habitat use and productivity of Canada geese breeding in the hydro development area. The other project is based on a concern that the major changes in freshwater flow into James Bay will affect water salinity and so change the distribution of eelgrass there. CWS plans to complete the mapping of James Bay eelgrass beds and establish the use of these areas by Atlantic Brant. The northern James Bay eelgrass beds are thought to be critically important to brant in their spring migration.

The Future

The North American Waterfowl Management Plan, in its present form, does not look beyond the year 2000. The goose population goals in the plan are simple: increase those geese that are now scarce, maintain (or reduce) those that are already abundant. As we try to understand and manage geese, in the Arctic Goose Joint Venture, we must go much deeper. We need a better appreciation of the reasons why some stocks are small, and likely to remain so. The reduction of some plentiful stocks is seen to combine the advantages of benefit from larger harvests while at the same time we reduce protests about crop damage. However, changes in distribution, which have been very substantial in many cases, are not usually under our control. The matching of demand to supply is a large part of goose management: put that way round deliberately, because the geese themselves choose where to live and their productivity is largely impossible for us to manipulate.

There seem few reasons to suppose that fine tuning of regulations and other management actions is necessary to ensure the continuing prosperity of geese in North America. A danger of that detailed approach is that it concentrates thought and resources on short-term ends. For geese, long-lived, highly mobile and adapting quickly to human change, it must be sensible also to think now about what they may find here in 40 or 50 years time. In an effort to think more easily about long-term changes, we are reviewing the effects of climatic variability on geese during the last 250 years as a way of putting the scenarios for a 2 × CO_2 world into perspective. There is, of course, not very much historical information on geese. There is no reliable information at all about the future.

Goose Surveys in North America: Current Procedures and Suggested Improvements

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Introduction

The North American Waterfowl Management Plan (NAWMP) recognizes 27 separate populations of geese in North America (U.S. Department of the Interior and Canadian Wildlife Service 1986). Three additional populations: the Vancouver, emperor and Mississippi Flyway giant, are generally recognized but because of their limited distribution are not included in the NAWMP. Geese constitute about 15 and 22 percent of the annual waterfowl harvest in the United States and Canada, respectively. The harvest of geese in Mexico is presently unknown. Geese differ from ducks in several important ways. Geese are longer-lived, exhibit stronger philopatry, have evolved a more permanent mating system and begin reproducing at a later stage of their life cycle than do ducks. The problems faced by goose managers are also markedly different in many respects than those faced by duck managers. Compared to ducks, geese are more prone to local overabundance (where they sometimes create nuisance problems), are more likely to be influenced by subsistance harvest, are less influenced by periodic drought conditions, are less affected by land use changes and are more prone to problems relating to distribution, particularly during fall and winter. Geese are numerically more manageable due to the clearer role of harvest in annual mortality, and because of their strong philopatry seem to have the capacity for more regionally-refined management than ducks.

The role of surveys in goose management will be determined by addressing the question: What is the minimum amount of information necessary for the management of harvested populations of migratory birds? The answer will vary, depending upon the degree of management desired. Martin et al. (1979) suggest that if all aspects of population regulation are well understood, then the minimum amount of information necessary is an annual population estimate. However, as they state, a major goal of migratory bird management is to predict future population changes. In order to accomplish this, we must gain a better understanding of the interrelationship between the parameters regulating goose populations. To achieve what appears to be the currently-desired level of management versatility, periodic estimates of population numbers, distribution, survival rates, recruitment rates and harvest rates for all distinguishable groups within each population are necessary. Such information can be gained via operational banding programs, population and harvest surveys. To a varying degree, these survey programs are presently in place for most goose populations in North America. Our objective is to (1) describe population and harvest survey information available for goose populations in North America, (2) present the current population status of these goose populations, (3) describe the harvest of geese in North America, (4) document major deficiencies in current population and harvest survey programs and (5) make suggestions for program improvements. The subject of banding is covered by another presentation in this session.

Methods and Materials: Types of Surveys

Harvest

A mail survey is conducted annually by the U.S. Fish and Wildlife Service (FWS) in the United States and by the Canadian Wildlife Service (CWS) in Canada, to estimate the activity and success of waterfowl hunters. These surveys have been described in detail for the U.S. by Martin and Carney (1977), Voelzer et al. (1982), Carney (1984), and Trost and Carney (1989), and for Canada by Cooch et al. (1978). Harvest estimates (FWS and CWS files) are presented for four major groups of geese: (1) Canada geese (*Branta canadensis*), combining all subspecies; (2) brant (*B. leucopsis* and *B. bernicla horta*); (3) snow geese (*Anser caerulescens caerulescens*, *A. c. atlantica*, and *A. rossii*); and (4) white-fronted geese (*A. albifrons frontalis* and *A. a. gambelli*). Harvest estimates for the United States are presented by the four administrative waterfowl flyways (U.S. Department of Interior 1975), and those for Canada for the three regions used by Trost et al. (1987) for the recent stabilized regulations assessment: (1) Eastern Canada—the provinces of Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland; (2) Prairie Canada—the provinces of Manitoba, Saskatchewan and Alberta; and (3) Northwestern Canada—the province of British Columbia, and the Yukon and Northwest Territories.

Mid-winter Survey

The main source of population information for most goose populations in North America is the mid-winter survey (MWS). This survey has been conducted since the mid 1930s (Martin et al. 1979, Smith et al. 1989). All survey data were obtained from CWS and FWS files.

Trend estimates of goose populations were determined by linear regression of population indices for 5 (1984–88), 10 (1979–88) and 20 (1969–88)-year periods. We employed three categories of trends indicating significant negative (−), positive (+) or no significant (0) trend based on the significance level of a t-statistic determined by dividing the regression coefficient by its standard deviation (Sokal and Rohlf 1981:473). We fully realize the severe limitations in this simplistic approach to describing changes in populations over time, but our objective was simply to portray the general direction of change for each population. The time comparisons are not independent and, because significance is partly a function of the number of years, (sample size) we would logically expect fewer significant short-term trends.

Breeding Ground Surveys

The cost of surveying breeding areas for geese is markedly higher than the costs associated with winter surveys, due primarily to the remoteness of areas that need to be inventoried. Not surprisingly, the first attempts at breeding ground surveys involved colonial nesting snow geese, as the area that needed to be covered was limited to known colonies (Kerbes 1975). These surveys, which began in the early 1970s, are still conducted periodically and employ aerial photography to estimate population numbers (Kerbes 1982). Recently, several independent groups have begun experimenting with breeding ground surveys for non-colonial nesting geese throughout the Arctic and subarctic regions of North America. The majority of these surveys have been for Canada goose populations (e.g., Malecki et al. 1981, Butler et al. 1988, Malecki and Trost in review); however, the attempt is also being made for white-fronted geese (Cole and Hines 1989) in the central Canadian Arctic. In addition to breeding population estimates, annual estimates of production are made for some Canada goose populations wintering in the Mississippi Flyway based on July surveys. Such surveys show promise, but as yet are still considered experimental. In general, breeding ground surveys can be considered as being a more rigorous statistical basis as they generally employ transect designs and variance estimation techniques that are patterned after the May breeding pair surveys conducted for ducks (Martin et al. 1979). We have not included any of these estimates in our analysis of population trends as most of these surveys are regarded as experimental and most have been conducted only in very recent years.

Surveys During Migration

Some goose populations are surveyed while in transit from breeding to wintering areas. Populations regularly indexed during fall or spring include: greater snow geese in the St. Lawrence estuary, emperor geese, and the Pacific Flyway population of greater white-fronted geese. Additionally, the index for the western mid-continent population of greater white-fronted geese is obtained by subtracting the mid-winter count for the eastern mid-continent white-fronted population from the combined index obtained from March counts in Nebraska where both populations stage together. We have used the indicies derived in this way to assess the population trends of emperor geese and both the western mid-continent and Pacific Flyway populations of greater white-fronted geese.

Results

Harvest Magnitude and Distribution: Canada Geese

Canada geese are one of the most numerous species of waterfowl harvested in North America. In 1988, only mallards (*Anas platyrhynchos*) outranked Canada geese in the U.S. harvest. They have ranked second or third overall in the North American waterfowl harvest during the last several years. However, recent years have been ones of markedly reduced duck harvests. Canada geese comprised about two-thirds of the total goose harvest in both Canada (66 percent) and the U.S. (63 percent) during the period 1969–88. The total Canada goose harvest has averaged 366,724 (SE = 20,379) in Canada and 1,037,227 (SE = 32,280) in the U.S. The U.S. harvest is about three-quarters of the Canada goose harvest in both countries. Within the U.S., the Atlantic Flyway has averaged the largest Canada goose harvest during the last 20 years ($\bar{x}$ = 347,822/yr.), followed by the Mississippi Flyway ($\bar{x}$ = 296,139/yr.), Central Flyway ($\bar{x}$ = 201,362/yr.) and finally the Pacific Flyway ($\bar{x}$ = 191,904/yr.). In Canada, the Prairie Provinces have averaged the largest Canada goose harvest during the last 20 years ($\bar{x}$ = 227,403/yr.) followed by Eastern Canada ($\bar{x}$ = 125,888/yr.) with Northwestern Canada ($\bar{x}$ = 13,432/yr.) having the lowest estimated harvest.

Trends in the harvest of Canada geese over the last 20 years have varied by region within countries. In the U.S., the Mississippi and Central Flyway harvests have increased ($P < 0.01$, Figure 1). The Atlantic Flyway does not exhibit a significant upward or downward trend for the 1969–88 period; however, this is not because harvests have remained relatively stable but rather because harvests increased markedly through the mid-1980s and have declined dramatically during recent years (Figure 1). In the Pacific Flyway, reduced Canada goose harvests since 1985 have resulted in a significant negative trend for the 1969–88 period (Figure 1). In Canada

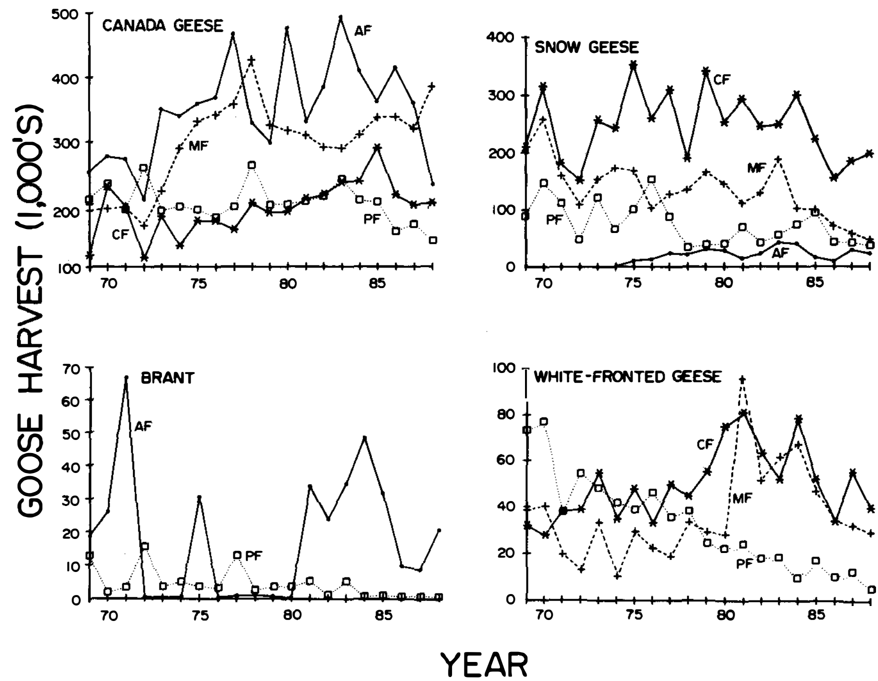

Figure 1. Numbers (1,000's) of brant, Canada geese, white-fronted geese and snow geese harvested in the Atlantic (AF), Pacific (PF), Central (CF) and Mississippi (MF) Flyways for the period 1969–1988 in the United States.

the harvest of Canada geese increased ($P < 0.01$) during the 1969–88 period in all three regions (Figure 2).

Harvest Magnitude and Distribution: Snow Geese

Snow geese were the second most numerous group of geese harvested in Canada and the U.S. for the period 1969–88. The harvest of snow geese averaged 124,018 (SE = 9,677) in Canada and 468,259 (SE = 25,593) in the U.S. during these years. Harvests of snow geese also vary markedly among regions within each country. Average snow goose harvests in the U.S. have been highest in the Central Flyway ($\bar{x}$ = 244,185/yr.), next highest in the Mississippi Flyway ($\bar{x}$ = 134,989/yr.) followed by the Pacific Flyway ($\bar{x}$ = 73,477/yr.) and lowest in the Atlantic Flyway ($\bar{x}$ = 15,609/yr.). In Canada, average harvests for the period 1969–88 were: Prairie Canada ($\bar{x}$ = 84,611/yr.), Eastern Canada ($\bar{x}$ = 37,252/yr.) and Northwestern Canada ($\bar{x}$ = 2,156/yr.). About 80 percent of the snow goose harvest occurs in the U.S.

Temporal trends in snow goose harvests also vary among regions in each country. In the U.S., snow goose harvests have increased ($P < 0.01$) in the Atlantic Flyway, remained stable in the Central Flyway, and declined ($P < 0.01$) in both the Mississippi and Pacific flyways during the period 1969–88. In Canada, snow goose harvests have increased ($P < 0.01$) in Prairie Canada and remained relatively stable in both Eastern and Northwestern Canada (Figure 2).

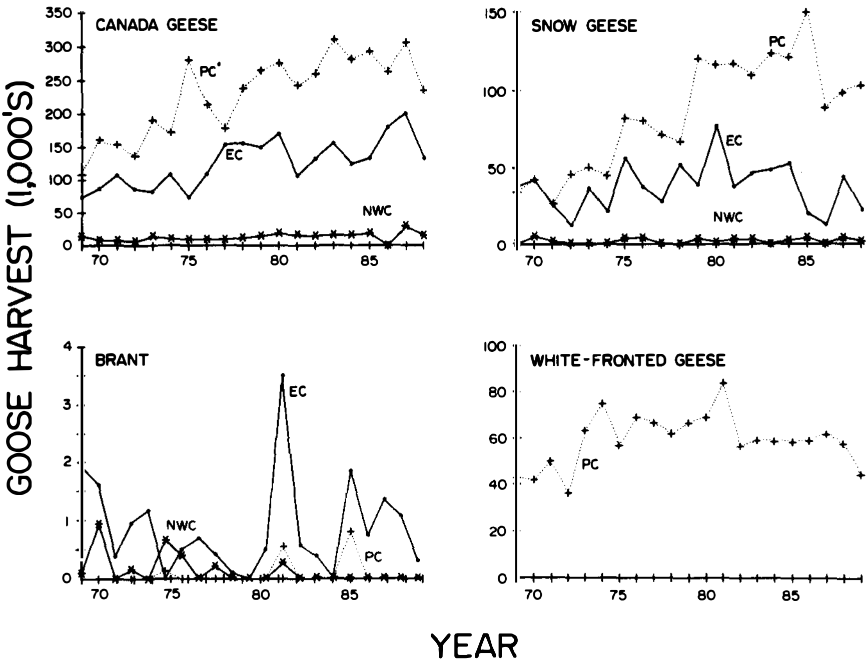

Figure 2. Numbers (1,000's) of brant, Canada geese, white fronted geese and snow geese harvested in Eastern Canada (EC), Prairie Canada (PC) and Northwestern Canada (NWC) for the period 1969–1988.

Harvest Magnitude and Distribution: Brant

Brant harvests constitute the smallest harvest by major goose group in Canada and the United States. Almost all brant harvest is restricted to the Atlantic and Pacific coastal regions in both countries. The average U.S. harvest for 1969–88 was 21,726 (SE = 4,112) while in Canada harvests averaged 1,001 (SE = 235). Brant harvests are very erratic, and only exhibit significant declines for the Pacific Flyway in the U.S. and the Northwestern Region of Canada.

Harvest Magnitude and Distribution: White-fronted Geese

The harvest of white-fronted geese has averaged 117,804 (SE = 6,509) in the U.S. and 60,127 (SE = 2,480) in Canada for the period 1969–88. Canada accounts for about one-third of the reported harvest of white-fronted geese and the U.S. about two-thirds. Proportionally, the harvest of white-fronted geese is greater in Canada than for any other group of geese. Regional trends in the harvest of white-fronted geese in the U.S. have shown increases ($P < 0.05$) in the Central Flyway, stable harvests in the Mississippi Flyway, and decreasing harvests in the Pacific Flyway ($P < 0.01$ Fig. 1). The Atlantic Flyway harvests very few white-fronted geese. In Canada, no long-term trends are evident (Figure 2).

Population Assessment and Status: Canada Geese

The NAWMP recognizes 15 distinct Canada goose populations in North America (Table 1). In addition to these, 2 other populations are generally recognized by goose managers, but because of their limited distribution were not included in the NAWMP. They are: Mississippi Valley giant Canada geese (*B. c. maxima*), and the Vancouver (*B. c. fulva*) population of Canada geese (Table 1). Of the 15 populations, 6 have been surveyed in each of the last 20 years, 3 have no organized survey program, and the remaining 6 have population surveys of varying completeness, with surveys being conducted between 8 and 19 of the last 20 years (Table 1). We have combined the great plains and western prairie populations in our tables because they overlap completely during the winter survey period.

Population Assessment and Status: Snow Geese

There are six populations of snow geese (including Ross' geese) generally recognized in North America. Of the six, three have no routine winter population surveys, one has had partial surveys over the last 20 years, and two have a complete survey history for the period 1969–88 (Table 2). The data for greater snow geese clearly indicate an increasing ($P < 0.01$) trend. It should be noted that the annual aerial photographic survey conducted by the Canadian Wildlife Service on the St. Lawrence estuary is regarded as far more accurate than the winter survey. However, the St. Lawrence data lead to the same conclusion about the general population trend. To maintain compatibility with other existing goose survey information, we have used the January estimates. The midcontinent population of snow geese increased during the 20-year period but has remained stable in recent years (Table 3). No other snow goose population survey figures suggest any significant population trends; however, winter survey data are incomplete or lacking for all other populations.

Table 1. Population estimates (in 1,000's) for the 17 North American Canada goose populations presently recognized. We have combined two populations the great plains and western prairie populations in this table because they overlap completely during the winter survey period.

	Canada geese															
Year	AFP	TVP	MVP	MAX(MF)	EPP	WP/GP	TGPP	SGPP[a]	H-LP[a]	RMP	PP[b]	PF-L[c]	DSKY	CACK	ALEU	VANC[c]
Survey month	Jan	Dec	Dec	Dec	Dec	Dec	Dec	Dec/Jan	Dec/Jan	Jan	Jul		Jan	Nov	Dec–Jan	
1969/70	775.2	106.9	324.7	50.8	106.6			152.0	44.0				22.5			
1970/71	675.0	127.3	292.3	64.4	126.3		133.0	145.0	41.0				19.8			
1971/72	700.2	117.6	293.9	55.8	157.4		161.0	156.0	31.0				17.9			
1972/73	712.0	101.3	295.9	54.2	181.4		148.0	257.0	36.0				15.8			
1973/74	760.2	136.0	277.9	57.6	205.8		161.0	150.0	24.0				18.6			
1974/75	819.3	101.0	304.4	57.0	197.1		134.0	116.0	36.0				26.5			
1975/76	784.5	115.5	304.9	62.1	204.4		204.0	233.0	49.0				23.0			
1976/77	923.6	129.8	478.5	58.5	254.2		171.0	198.0	63.0				24.1			
1977/78	833.2	180.4	575.5	60.1	270.2		216.0	119.0	63.0	60.0			24.0		1.6	
1978/79	823.6	142.7	434.5	77.1	207.2		188.0	155.0	34.0	62.5			25.5		1.6	
1979/80	780.1	127.0	394.9	86.4	171.8		166.0	197.0	68.0	66.2			22.0	64.1	1.8	
1980/81	955.0	120.3	367.4	102.9	150.9		258.0	155.0	89.0	91.0			23.0	127.4	2.1	
1981/82	702.6	118.5	250.9	107.6	145.3	175.0	285.0	149.0	87.0	71.1			17.7	87.1	2.8	
1982/83	888.7	129.9	303.7	149.9	210.4	242.0	172.0			73.1			17.0	54.1	3.6	
1983/84	822.4	129.9	352.8	103.9	162.7	150.0	280.0			61.6			10.1	26.2	3.9	
1984/85	814.2	129.3	477.2	151.7	167.6	230.0	207.0			88.4			7.5	25.8	4.3	
1985/86	905.4	158.0	618.9	180.1	169.0	115.0	198.0	173.0		66.3			12.2	32.1		
1986/87	754.8	129.8	514.6	231.9	182.7	324.0	163.0	221.0	96.0	66.2				51.4	5.0	
1987/88	737.9	158.8	564.6	225.9	228.4	272.0	316.0	147.0	102.0	71.4			12.2	54.8		
1988/89	660.7	170.2	734.6	252.2	184.5	330.0	224.0	266.0	106.0				11.8	69.9	5.6	

[a]January surveys through 1981/82, December surveys thereafter.
[b]Numerous objectives for local breeding flocks; no overall population survey conducted.
[c]No routine surveys to monitor population status.

Table 2. Population estimates (in 1,000s) for the North American populations of snow geese, greater white-fronted geese and brant.

Year	Snow geese					Ross' geese	Greater WF geese				Brant		Empr geese
	GRTR	M-C	W-CF[b]	W-CA[c]	WR IS[a]		E-MC	W-MC[e]	PF	TULE[a]	ATL	PAC[d]	
Survey month	Jan	Dec	Dec	Jun			Dec	Mar	Nov		Jan	Jan	Mar–Apr
1969/70		818.7					50.6	85.4				141.7	
1970/71	49.0	1,067.3					39.3	128.5			151.0	149.2	
1971/72	81.0	1,331.8					45.8	38.6			73.0	124.8	
1972/73	59.0	1,025.3					43.0	131.0			41.0	125.0	
1973/74	95.0	1,189.7					43.2	157.5			88.0	130.7	
1974/75	70.0	1,096.9					40.4	133.2			88.0	123.5	
1975/76	117.0	1,562.4					53.4	127.0			127.0	122.1	
1976/77	127.0	1,150.3	34.0				50.4	204.4			74.0	147.0	
1977/78	74.0	1,967.0	31.0				53.1	283.6			46.0	162.9	
1978/79	100.0	1,285.5	29.0				49.3	250.6			44.0	129.4	
1979/80	107.0	1,387.7	30.0				59.0	245.0	73.1		69.0	146.4	
1980/81	81.0	1,406.3	37.0				67.5	71.4	93.5		97.0	194.2	93.3
1981/82	72.0	1,794.0	50.0				65.6	233.9	116.5		106.0	121.0	100.6
1982/83	82.0	1,755.5	76.0				62.0	201.3	91.7		124.0	109.3	79.2
1983/84	99.0	1,494.4					70.3	6.6	112.9		127.0	133.4	71.2
1984/85	187.0	1,973.1	63.0				81.3	72.7	100.2		146.0	144.8	58.8
1985/86	100.0	1,449.3	97.0				78.6	100.4	93.8		110.0	128.5	42.0
1986/87	102.0	1,913.8	64.0				71.5	144.3	107.1		111.0	128.5	51.7
1987/88	198.0	1,750.5	46.0				76.7	95.4	130.6		131.0	138.6	53.8
1988/89	192.0	1,956.1	74.0				116.5	99.4	161.5		138.0	128.1	45.8

[a]No routine surveys to monitor population status.
[b]January surveys also were conducted in Mexico in some years. Estimates were: 1976---79,000; 1978—85,000; 1979—55,000; 1981—61,000. W-CF estimates contain small proportions of Ross' geese.
[c]No routine surveys; status assessment based on intermittent breeding grounds surveys.
[d]In 1986/87, Mexico brant survey was delayed, producing questionable results; 1985/86 estimate was used.
[e]Both W-MC and E-MC whitefronts stage in Nebraska during spring migration. W-MC indices are derived from the March survey by subtracting Dec. E-MC estimates from March survey results. March survey incomplete in some years, e.g., 1971/72, 1980/81, and 1983/84.

Table 3. Population trends in North American goose populations as determined by linear regression of annual population surveys presented in tables 1 and 2.

Population	Trend estimate[a] 20 years (1969–88)	10 years (1979–88)	5 years (1984–88)	Population index (1988–1989)	NAWMP goal
Canada geese					
Atlantic Flyway	0	0	–	660.7	850.0
Tennessee Valley	+	+	0	170.2	150.0
Mississippi Valley	+	+	0	734.6	500.0
Miss. Flyway Giants	+	+	+	252.2	not listed
Eastern Prairie	0	0	0	184.5	200.0
W. Prairie/Great plain	*	*	0	330.0	250.0
Tallgrass Prairie	+	0	0	224.0	250.0
Shortgrass Prairie	*	*	0	266.0	150.0
Hi-line	+	+	+	106.0	80.0
Rockey Mountain	*	0	0	*	50.0
Pacific	*	*	*	*	29.0
Pacific Flyway Lesser	*	*	*	*	125.0
Dusky	–	–	0	11.8	20.0
Cackler[b]	*	0	+	69.9	250.0
Aleutian	*	+	+	5.6	delist
Vancouver	*	*	*	*	not listed
Snow geese					
Greater	+	+	0	192.0	185.0
Midcontinent	+	0	0	1,956.1	1,000.0
Western Central Flyway	*	0	0	74.0	110.0
Western Canadian Arctic	*	*	*	*	120.0
Wrangle Island (USSR)	*	*	*	*	200.0
Ross' geese	*	*	*	*	100.0
Greater white-fronted geese					
Eastern Midcontinent	+	+	0	116.5	65.0
Western Midcontinent	0	–	0	99.4	250.0
Pacific Flyway	*	+	+	161.5	300.0
Tule	*	*	*	*	5.0
Brant					
Atlantic	+	+	0	138.0	124.0
Pacific	0	0	0	128.1	185.0
Emperor	*	–	0	45.8	not listed

[a]Trend estimates were determined as; no significant trend (0), a significant negative trend (–), or a significant positive trend (+). Significance ($P < 0.05$) was determined by a t-statistic derived from the linear regression of population indicies on years. * indicates insufficient data for trend estimation.
[b]Although no coordinated survey information exists for the period 1969–79 for cackling Canada geese, data from the Klamath basin indicates a marked long term decline in the numbers of this population since 1979 (Raveling 1984).

Most of the additional information on the status of snow goose populations is derived from the periodic photographic surveys of the breeding colonies conducted at five-year intervals (Kerbes 1975). These photographic surveys generally support the midwinter estimates but provide far more detail on individual colonies.

Population Assessment and Status: Brant

Both North American brant populations have been surveyed in at least 19 of the last 20 years. Numbers of Atlantic brant have been increasing ($P < 0.05$) while numbers of Pacific Brant have remained fairly constant (tables 2 and 3). No breeding ground surveys presently exist for either brant population.

Population Assessment and Status: White-fronted Geese

Two of the four North American populations of white-fronted geese have complete survey histories for the period 1969–88 (tables 2 and 3). One, the Tule population is not routinely surveyed, while the Pacific Flyway population has been surveyed for the last 10 years (Table 1). The mid-winter surveys suggest that numbers of white-fronted geese have been increasing in the eastern-midcontinent and Pacific populations, but declining in the western-midcontinent population (tables 2 and 3).

Discussion

Goose managers face a similar dilemma to that discussed by Babcock and Sparrowe (1989) for duck managers. The dilemma is: How much geographic refinement can management agencies afford? Presently, about one-quarter of the goose populations in North America have no operational population survey program (tables 1 and 2). No goose population has a specific operational harvest survey program. No harvest survey adequately addresses the magnitude of subsistence harvest in either the U.S. or Canada.

Eleven of the goose populations presented in tables 1 and 2 are comprised of a single subspecies of goose and include all members of that subspecies. The remaining 19 populations are comprised of several subspecies or of part of the total population of a single subspecies. Much of the difficulty in goose management stems from our use of the term, "population." As discussed by Mayr (1976:82) the term, "population," can be used to mean vastly different groups of individuals, from local panmictic breeding populations to aggregations of several species that share a specific geographic range. We feel it is important to define what we think constitutes a population of geese for management purposes. A manageable goose population is:

> *A group of geese, of a single species, whose breeding site fidelity, migration routes and wintering areas are temporally stable, sufficiently distinct geographically (at some time of the year), and adequately described so that the population can be monitored when various management strategies or other factors act to alter the population status.*

The number of populations of geese identified for management purposes has changed over time and will undoubtedly continue to change in the future. For example the NAWMP recognizes only one population of Canada geese in the Atlantic Flyway. Bellrose (1976) recognizes two, a North Atlantic and a mid-Atlantic. The Atlantic Flyway management plan presently is being revised to recognize three populations, the Atlantic, a resident giant (i.e., *B.c. maxima*) population, and an Atlantic Flyway component of the Tennessee Valley population of the Mississippi Flyway. Presently both the Atlantic and Mississippi Flyway Council technical sections are considering renaming the Tennessee Valley population the southern James Bay population, based on the breeding range of these geese. Most areas of the country are undergoing similar re-evaluations of the Canada goose population definitions in their areas.

The changing definitions of the various flyway goose populations, coupled with the lack of racial integrity in many of these groups of geese, contributes to the principal difficulties with goose surveys (both harvest and population). Even in cases where an entire subspecies is considered a population, they are often surveyed at times and places when their distribution overlaps that of other populations. Differentiation of the various populations is extremely difficult if not impossible in many instances. Harvest-survey information is even less well suited to the large number of goose populations we are presently trying to monitor. In most instances we cannot provide harvest information by population. This is because at present we lack the ability to discriminate between geese from various populations in the parts-collection surveys. One approach that has been used to address this problem is to partition harvest-survey information geographically, based on band-recovery information. However, this procedure requires an operational preseason banding program in all goose populations contributing to the harvest in a specific area. To date, such extensive preseason banding of geese has not been available for most areas.

Operational annual production surveys do not exist for any Canada goose population in North America. Presently, production is qualitatively assessed through satellite imagery. In recent years, this information has been verified by qualitative observations in parts of the Canadian Arctic (Nieman and Reynolds 1989). The only quantitative information on annual production rates for many populations of geese is found in the immature to adult ratios obtained from the parts collection surveys in the U.S. and Canada.

The Future

We feel future survey needs for geese should be directed at achieving the following goals: (1) all populations should meet the definition of a goose population suggested above (i.e., they must be capable of being monitored separately); (2) operational population survey programs should be instituted for all recognized goose populations at a time when they are geographically distinct from all other goose populations; (3) research should be directed at refining harvest-survey information to the population level; (4) research should also be undertaken to develop a quantitative approach to annual production for Arctic and subarctic-nesting geese (likely based on a remote-sensing approach). We will probably never know all we would like to about any goose population. However, we believe that improved population, production and harvest estimates, coupled with an operational banding program in specific populations, can go a long way toward ensuring the continued existence of our valuable North American goose resources well into the next century.

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Estimating Population Parameters for Geese from Band-recovery and Mark-recapture Data

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Introduction

Proper management of geese requires information. Aerial surveys can provide indices of population size, but to understand what causes population size to change, information is needed about changes in reproductive recruitment, survival, emigration and immigration rates. Information on changes in these demographic parameters can be obtained through the analysis of band-recovery and mark-recapture (resight) data. These data can be collected for individual geese that are banded on breeding, molting, migration and wintering areas with either standard aluminum leg bands (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1984) or with leg bands and individual, observable tags, most notably neck bands or neck collars (Helm 1955, Craighead and Stockstad 1956, Ballou and Martin 1964, Sherwood 1966a, MacInnes et al. 1969).

The earliest analyses of band-recovery data were used to establish the existence of the four flyways (Lincoln 1935, Jensen 1949, Crissey 1955). Later studies have used band-recovery data to discern breeding and winter ground affiliations and migration corridors for different populations of geese and to estimate survival rates, recovery rates (indices of harvest rate), chronology of migration, and the distribution and derivation of the harvest (Hanson and Smith 1950, Vaught and Arthur 1965, Vaught and Kirsch 1966, Dimmick 1968, Chapman et al. 1969, Grieb 1970, Hanson and Eberhardt 1971, Szymczak 1975, King and Hodges 1979, Krohn and Bizeau 1980, Ball et al. 1981, Sheaffer and Malecki 1987).

When neck bands were first introduced, Aldrich and Steenis (1955) concluded that neck bands would be useful for obtaining information on behavior, local movement and local biology of birds, but that the use of neck bands was not a substitute for the use of leg bands. In early studies, researchers followed this recommendation and used mark-resight data primarily to examine the local biology of geese and to supplement leg band data on defining migration corridors and distributions for wintering and breeding populations (Martin 1964, MacInnes 1966, Sherwood 1966a, Dimmick 1968, Koerner et al. 1974, Raveling 1978, 1979, Prevett and MacInnes 1980, Craven and Rusch 1983). The use of neck bands for flyway-wide studies (Rusch in the Mississippi Flyway and Malecki in the Atlantic Flyway) arose largely from the frustration associated with low direct recovery rate for leg-banded geese (approx. 2–7 percent) and from problems associated with sampling by harvest. With a flyway database, new methodologies were needed and developed to estimate population number, survival, recovery and movement rates from mark-resight data (Cormack 1964, Craven et al. 1985, Brownie and Pollock 1985, Sullivan et al. 1989, Hestbeck and Malecki 1989a,b, Hestbeck et al. 1990).

Our objective is to review the methodologies used to discern breeding and winter ground affiliations and migration corridors and to estimate migration chronology, population number, distribution and derivation of the harvest, and survival, recovery and movement rates from band-recovery or mark-recapture (resight) data. In our discussion, we will compare and contrast the methods and inferences available from data collected from leg-banded and neck-banded geese.

Band-recovery Data

Geese have been banded with aluminum leg bands on the breeding, molting, migration and wintering areas. Sampling of leg-banded geese occurs through the sport harvest and is therefore inexpensive and widespread. Geese are shot, retrieved, and reported to the Bird Banding Laboratory, Laurel, Maryland. The information collected from banding and from the subsequent recovery constitutes the basic unit of data from which population affiliations are defined, harvest information is summarized and demographic parameters are estimated.

Breeding and Wintering Grounds and Migration Corridors

Analyses of the geographic distribution of band recoveries from different banding sites help to identify migration corridors, to assign specific banded samples to different populations or subspecies, and to determine breeding and wintering ground affiliations for given populations (Hickey 1951, Crissey 1955). Direct recoveries (recoveries made during the first hunting season after banding) are generally more useful for determining affiliations since these recoveries are from geese that are known to be associated with a particular breeding area. Indirect recoveries (recoveries made after the first hunting season following banding) are also useful, but some recoveries may be reported for geese that are associated with a different breeding area than the initial banding area. Accordingly, migration patterns determined from indirect recoveries have greater variation.

The geographic distribution of recoveries can be misleading if birds traveling or wintering in different areas have large differences in the probability of being recovered. Geographic differences in recovery rates can result from geographic differences in hunting pressures, in retrieval rates of harvested birds, or in reporting rates of banded birds. Raveling (1978) found that the distribution of recoveries for giant Canada geese (*Branta canandensis maxima*) masked the decline of one segment of the population and the expansion of another. Ratti and Timm (1979) reported that due to a substantially different harvest pressure in Oregon than in southeast Alaska, the recovery distribution misrepresented the sedentary behavior of Vancouver Canada geese (*B. c. fulva*).

Two methodologies have been used to test hypotheses that two banded samples have the same geographic distribution of recoveries. The geographic area can be divided into subregions (degree blocks, management units, states, or provinces). The proportion of recoveries occurring in each subregion for the two banded samples is then compared using a chi-square contingency table (Cowardin 1977, Snedecor and Cochran 1980:200–201). For the other method, Mardia's nonparametric test is used to directly compare the latitude and longitude coordinates of recoveries from two banded samples (Batschelet 1972:80–83, 1978). Several examples of Mardia's test using band-recovery data are provided by Nichols and Haramis (1980), Nichols et al. (1983), and Nichols and Hines (1987).

Distribution of Harvest

An important element of managing goose populations is to provide fair and equitable opportunity of hunting among the states and provinces in each flyway. To facilitate this goal, it is important to estimate the distribution of the harvest among the states and provinces (Geis 1972a,b, Sheaffer and Malecki 1987). First, a distribution of recovery rates for a given banded population is estimated by dividing the number of recoveries that occur in each harvest unit by the total number of geese banded in the population. As before, the use of direct recoveries provides a more accurate estimate because they ensure that a bird was within a given banding area that year. Next, the recovery rates for each subunit are multiplied by an estimate of the population size of the banded population. The estimates of population size are generally determined by another survey. If an estimate of the population size is not available, it is important to note that the distribution of recovery rates contains much of the information needed to determine the distribution and equitability of the harvest. If more than one population has been banded, this procedure should be followed for each banded population.

Several assumptions are required to estimate the distribution of harvest: (1) banded samples are representative of the banded populations, (2) reporting rates are equal for all harvest areas, and (3) the size of all banded populations is known.

Derivation of Harvest

Often, due to specific agreements among states or international treaty obligations, it is important to know the relative importance that particular breeding populations have to the harvest in a given state or province (Geis 1972a,b, Munro and Kimball 1982, Sheaffer and Malecki 1987). To estimate the number of birds from different banded populations that are harvested in a given harvest unit, the total number of recoveries from each banding area is recorded for the given harvest unit. Because the number of recoveries appearing in the harvest depends on the number of bandings in each area, each recovery must be weighted by the ratio of relative population size to the number of birds banded. The estimated harvest from each banding area is then estimated by multiplying the number of recoveries from each banding area by the ratio of population size to number banded. The probability that a goose originated in a certain banding area given that it was shot in a particular harvest unit can also be estimated by dividing the number of weighted recoveries for each banding area by the total number of weighted recoveries in the harvest area.

The three ssumptions required to estimate the derivation of harvest are also required for the estimation of the distribution of harvest. In addition, a fourth assumption requires that a banded sample of birds exists for all populations which occur in the harvest.

Migration Chronology

Band-recovery data can provide a rough idea of the timing of migration in geese (Krohn and Bizeau 1980, Ball et al. 1981). As geese migrate southward during a hunting season, hunters harvest geese and report banded individuals. The latitude and longitude coordinates of recoveries for a given date can be used to estimate the median location of a population for that date. The median location over time thus represents the chronology for the migration. This method has several problems. Low recovery rates for geese provide few useful data. Differential harvest pressure can bias the estimated location. Also, geese may be present in an area before the hunting season has commenced. For example, late hunting seasons in more southerly states can delay reporting of recoveries and hence of location by more than a month.

Survival and Recovery Rates

Brownie et al. (1985) have developed a series of models to estimate survival and recovery rates from band-recovery data. Survival rate for year i is defined as the probability that a bird alive at the time of banding in year i survives until the time of banding in year $i + 1$. Recovery rate for year i is defined as the probability that a bird alive at the time of banding in year i is shot or found dead during the hunting season of year i and its band number is reported to the Bird Banding Laboratory. Recovery rates are important to managers because estimates based on pre-season bandings can be used as an index of harvest rate (Henny and Burnham 1976, Conroy and Blandin 1984).

To estimate annual survival and recovery rates, birds are banded in a given population unit at yearly intervals either before the harvest on the breeding grounds (pre-season) or after the harvest on the wintering grounds (post-season). Estimates of survival and recovery rates are computed for samples containing only adult birds by program ESTIMATE and for samples containing bandings from young and adults by program BROWNIE (Brownie et al. 1985). These computer programs compute maximum likelihood estimates under several different models, goodness-of-fit tests, and likelihood ratio tests to compare models.

Several assumptions are required to make these estimations (Brownie et al. 1985:6): (1) the banded sample must be representative of the target population, (2) age and sex of individuals are correctly determined, (3) bands are not lost, (4) survival is not affected by banding, (5) band recoveries are correctly recorded, (6) the fate of each banded bird is independent of other banded birds, (7) the fate of a banded bird can be described as a multinomial random variable, and (8) all banded birds of an identifiable class have the same annual survival and recovery rates. Specific assumptions about variation of survival and recovery rates among years and between identifiable age classes are incorporated in each model.

Assumption number one requires that the sample is representative of the population. For a given experiment, a sample of birds is banded, the band-recovery data are analyzed, conclusions are drawn based on the sample, and the conclusions are inferred to apply to the larger population. If the sample is not representative of the larger population, the inferences drawn may be incorrect. This assumption can be violated if the bands affect the probability of survival or recovery of birds. For geese, using standard banding procedures, leg bands should not affect survival or recovery. This assumption can also be violated if significant heterogeneity exists among segments of a population and the heterogeneity is not represented in the sample. The effects of heterogeneity within a banded sample will be discussed under assumption eight. Efforts should be made to collect a representative sample. Sampling should be as random as possible in both time and space. If heterogeneity is suspected to exist between segments of a population, the population should be stratified and sampling within each stratum should be random.

Assumption number two is very important if variation in survival and recovery rates exists among age and sex classes. If variation exists between identifiable age and sex classes, the classes should be analyzed separately. If age and sex classes cannot be distinguished, a random sample should be taken to reduce heterogeneity that may occur during banding. For geese, sex-specific differences in survival rates are generally believed to be small because male and female geese have similar plumage and adult males and females remain paired throughout the year. Sex-specific differences in survival for Canada geese were not found during a nine-year mark-recapture study at Old Hickory Lake (Nichols et al. 1981) and during a seven-year band-recovery study in the Mississippi Flyway (Samuel et al. 1990).

Assumption number three concerns band loss. Although some degree of band loss will always occur, under normal conditions, leg-band loss will be very low so the resulting negative bias on survival rates will be insignificant (Nelson et al. 1980, Seguin and Cooke 1983).

The fourth assumption regarding the effect of banding is important because the banded sample is assumed to represent the entire population. If the banded sample experiences a high mortality due to banding, inferences drawn from the sample may be incorrect. This assumption is most likely met if geese are banded using standard procedures.

The fifth assumption concerns the correct tabulation of recoveries. Errors are probably infrequent and should not cause major problems for most applications (Anderson 1975). If hunters delay reporting a band recovery for one or more seasons, a negligible positive bias will result in most situations (Anderson and Burnham 1980).

For the sixth assumption, the fate of each banded bird is independent of the fates of other banded birds. This assumption will be violated for geese because geese are not independent entities (Sulzbach and Cooke 1978). Although this does not bias any estimators, the true sampling variances are larger than those computed from the statistical models for the data (Pollock and Raveling 1982).

Assumption number seven requires that the fate of a banded bird can be described by a multinomial random variable. This follows from the assumption of independence.

Assumption eight is that all banded birds of an identifiable class have the same annual survival and recovery rates. Natural populations of geese will have heterogeneous survival and recovery rates even within an age-sex class. Different segments of Canada goose populations use different sites within staging and wintering areas, and different segments also use these sites at different times (Raveling 1969a, 1978, 1979). Because harvest pressure varies among states and among regions of a given state, the different segments of a population will be exposed to differential harvest pressure. If heterogeneity exists only in recovery rates, there will be no bias in estimated survival rates and in the estimated mean recovery rate (Pollock and Raveling 1982). If heterogeneity in survival rates is small, the most likely situation, the bias in the estimated survival rates will be small relative to the standard errors of the survival estimates and will not cause serious problems (Nichols et al. 1982). But, if the heterogeneity in survival rates is large, a positive bias will occur in the estimated survival rates when survival and recovery rates are uncorrelated or positively correlated (common in winter banding) and a negative bias will occur in the estimated survival rate when survival and recovery rates have a negative correlation (common in pre-season banding) (Nichols et al. 1982). The bias will be more severe for long lived species and for studies of short duration (Pollock and Raveling 1982).

Hypotheses about geographic, temporal, age-specific, sex-specific, or other sources of variation in survival and/or recovery rates can be tested using between model tests (White 1983, Brownie et al. 1985) or using the point estimates with their associated variances and covariances (Brownie et al. 1985:180–182, Sauer and Williams 1989, Hines and Sauer 1989).

Brownie et al. (1985:183–193) provided several useful recommendations for designing a banding study to estimate survival and recovery rates. In addition, the number of bandings required for a given level of precision for estimates of survival rate can be computed using methods described by Wilson et al. (1989).

Although survival and recovery rates can be estimated from band-recovery data using the models of Brownie et al. (1985), the precision of the estimates is sometimes sufficiently low that the estimates are of limited use. Precision of the estimates based on these models depends largely on the number of banded birds that are eventually recovered. For geese, direct recovery rates are generally low (approx. 2–7 percent). For example, survival and recovery rates were estimated for Canada geese neck-banded and leg-banded in the mid-Atlantic (New York, Pennsylvania, New Jersey), Chesapeake (Delaware, Maryland, Virginia), and Carolina (North Carolina, South Carolina) regions of the Atlantic Flyway using band-recovery data and the models of Brownie et al. (1985). Only normal, wild geese banded postseason (after January 31) during 1984–88 were used in the analysis. Recoveries were restricted to geese shot or found dead during the hunting season (Sept.–Jan.). In total there were 3,097 bandings in the mid-Atlantic with 274 recoveries, 6,687 bandings in the Chesapeake with 501 recoveries, and 2,163 bandings in the Carolinas with 166 recoveries. Model M1 fit the data from all three regions (mid-Atlantic $P = 0.908$; Chesapeake $P = 0.923$; Carolinas $P = 0.096$). The average annual recovery rates for the double banded geese were 0.0472 ($\widehat{SE} = 0.0042$), 0.0365 (0.0023), and 0.0418 (0.0043) for the mid-Atlantic, Chesapeake, and Carolina regions, respectively. The estimated annual survival rates ranged from 0.409 (0.131) to 1.314 (0.815) (Table 1).

In summary, in situations where geese exhibit low recovery rates, inferences about annual estimates of survival rate will never be very strong. In this example, the recovery rates for these double-banded geese were most likely higher than those for geese banded with only leg bands because of higher reporting rates (Samuel et al.

Table 1. Comparison of estimated survival rates ($\hat{\phi}_i$) and standard errors from band-recovery data of N_b leg-banded geese and from mark-resight data of N_r neck-banded geese. Data are from double-banded Canada geese in the Atlantic flyway 1984–87.

	Band-recovery			Mark-resight		
	N_b	$\hat{\phi}_i$	$\hat{SE}[\hat{\phi}_i]$	N_r	$\hat{\phi}_i$	$\hat{SE}[\hat{\phi}_i]$
Mid-Atlantic						
1984	425	0.725	0.148	122	0.667	0.103
1985	882	0.661	0.103	1654	0.685	0.029
1986	1128	0.562	0.120	1750	0.747	0.047
1987	398	1.314	0.815	1230	0.566	0.025
$\bar{x}$		0.815	0.202		0.666	0.030
Chesapeake						
1984	1338	0.906	0.107	1294	0.728	0.023
1985	2510	0.780	0.111	2833	0.756	0.018
1986	1055	0.569	0.103	2414	0.694	0.022
1987	1086	0.764	0.247	2019	0.627	0.021
$\bar{x}$		0.755	0.063		0.701	0.011
Carolinas						
1984	401	0.454	0.114	276	0.717	0.053
1985	660	1.172	0.338	653	0.672	0.042
1986	287	0.409	0.131	513	0.704	0.042
1987	593	0.734	0.409	826	0.645	0.035
$\bar{x}$		0.692	0.118		0.684	0.022

1990). The most that can be hoped for using band-recovery data from samples with low recovery rates is a relatively precise estimate for average annual survival over a number of years.

Mark-recapture Data

Geese can also be marked with individual, observable tags, most notably neck bands (Helm 1955, Craighead and Stockstad 1956, Ballou and Martin 1964, Sherwood 1966a, MacInnes et al. 1969). In contrast to the sampling of leg-banded geese through the harvest, sampling of neck-banded geese is conducted by project observers. Consequently, sampling is more expensive and localized than for leg-banded geese, but sampling can now be controlled by the researcher. The researcher is thus responsible for collection, processing, and maintenance of the data. To ensure that neck-band sampling is representative of the population, the survey area must be defined and the entire survey area should be sampled by the project observers.

Generally, more observations can be made of neck-banded geese and multiple observations of individual geese are possible. Despite this benefit, potential problems resulting from the use of neck bands include starvation (Ankney 1975, 1976, but *see* Raveling 1976), possible behavioral changes, increased error rate of observations, higher tag loss, and ice buildup on the neck bands. The increased error rate due to observation can be reduced by holding ''observer workshops'' to instruct project observers about problems they will encounter in the field and about the danger of ''guessing'' when the entire neck-band code cannot be read.

Although neck bands have the potential to affect behavior, neck bands appear to have no significant effect on the behavior of geese (Sherwood 1966a, Raveling 1969b, Prevett and MacInnes 1980, Johnson and Sibly 1989). However, lesser snow geese (*Anser c. caerulescens*) have mutilated neck bands (MacInnes et al. 1969), and neck bands may inhibit reproduction in black brant (*B. bernicula nigricans*) (Lensink 1968).

Neck bands have a significant loss rate that depends on the species banded, age and sex class, and material used (Fjetland 1973, Zicus and Pace 1986, Samuel pers. comm.). Workshops should be held before a study begins to instruct the banders about the placement of neck bands, the use of adhesives and ideal drying conditions for the adhesives. Because a significant neck-band loss can occur, it is important to realize which estimation procedures will be biased by the tag loss. If biases occur, the retention rate must be estimated to correct for tag loss. Estimation of retention rates is covered more fully in the section on survival rates.

Ice can form on neck bands and may collect to create large ice balls (MacInnes et al. 1969, Greenwood and Bair 1974, Craven 1979). MacInnes et al. (1969) found that freezing rain created an initial layer of ice and subsequent immersion in water caused large ice balls to develop. Craven (1979) found that icing on neck bands resulted from bathing or wave action in open water at temperatures around −17°C. Generally, icing of neck bands does not appear to cause significant levels of mortality (Greenwood and Bair 1974, Craven 1979). However, neck-band icing can be a serious mortality factor in the Midwest and Great Plains regions of the United States during the late fall (Zicus et al. 1983). In the Atlantic Flyway, icing-related deaths are rare (111 known icing deaths from 29,831 neck bands) and generally occur in unnatural settings (cooling ponds, aerated ponds). For populations in which researchers expect to experience higher levels of icing, research is presently being conducted on neck bands that will be more resistant to ice build-up. E. Hayakawa (Canadian Wildlife Service, pers. comm.) has conducted tests using environmental chambers which have exposed a large variety of neck bands to 10°C and water mist. Hayakawa found that ice builds up on all neck bands under these conditions, but because rubber neck bands flex, they have the potential to break thin films of ice and thus prevent significant ice buildup. Field tests of the rubber neck bands in Ontario and Maryland will explore their feasibility and possible benefits of reducing icing. H. Funk (Colorado Division of Wildlife, pers. comm.) has used rubber neck bands and found that retention was high and no neck bands were observed with ice.

Breeding and Wintering Grounds and Migration Corridors

Breeding and wintering ground affiliations and migration corridors can be identified through an analysis either of the geographic distribution of leg-band recoveries or of observations of neck-banded geese (Craven and Rusch 1983, Malecki and Trost 1986). Generally, more data can be collected from neck-banded geese; observer effort can be controlled such that sampling can be more uniform; and observations can be made when geese first arrive on the wintering or breeding areas. The chi-square contingency table and Mardia's nonparametric test can both be used to test for differences in the distributions of observed geese. As with band-recovery data, the geographic analysis can be biased if large differences in the probability of observation exist among sampling areas.

Migration Chronology

Migration chronology can also be obtained from observation data. As geese migrate, observers record the latitude, longitude and date of resighting neck-banded geese. The median location of the population over time provides an estimate of the migration chronology for that population. Estimates based on observation data are an improvement to those obtained from recovery data because geese have a low recovery rate and harvest pressure varies among harvest areas. However, the observation estimate still has problems. Geese may bypass observers. Differential observer effort can bias the estimate. Also, geese may be present in an area for an unknown period of time before being observed. These problems are more serious for more dispersed species of geese and less serious for colonial breeding species because the colonial breeders appear also to concentrate during migration and on the winter grounds.

Precise estimates of the chronology of migration can be very useful for managers who want to reduce harvest on threatened population segments by curtailing harvest in certain areas, allowing segments to migrate through the harvest areas. Observation data can provide an approximate estimate of migration chronology. However, precise estimates may have to wait for the development of reliable, lightweight, satellite-received, radio telemetry.

Population Number

Traditionally, estimates of population number have been made by attempting to completely enumerate all individuals in a population or by developing an index of population number. Examples of this are the fall and midwinter aerial surveys or photographic survey. Population number can also be estimated using mark-recapture data (*see also* Nichols et al. 1981, Pollock 1981a, Seber 1986). Mark-recapture models are classified according to their assumption of population closure. Open population models allow recruitment, mortality or movement to occur during an experiment, while closed population models assume these demographic variables remain unchanged during an experiment. As a consequence, closed population models can be used for experiments that occur over a short period of time, and open population models can be used for experiments that are conducted over longer periods of time.

Petersen around 1900 (White et al. 1982:17) and Lincoln (1930) were among the first to use a closed population model to estimate population size for animal populations. Their model has two sampling periods. A first sample of n_1 birds is taken from a population of size N. Individuals in the sample are marked and returned to the population. The number marked from the sample represents the known number of marked birds in the entire population, M. Sufficient time is allowed for the marked birds to completely mix with the unmarked individuals. Then a second sample of n_2 is taken from the population, and the number of marked individuals (m_2) is recorded. The number of birds in the population relative to the number of marked birds in the population is estimated as the ratio n_2/m_2. Population size is then estimated as the product of the ratio and of the number of marked birds in the population:

$$\hat{N} = \widehat{(N/M)}\, M = \frac{n_2}{m_2} M.$$

The Lincoln-Petersen estimator requires the following assumptions (Seber 1982): (1) the population is closed, (2) all birds have equal probability of capture for each sampling period, and (3) marks are not lost. Violation of different assumptions has varied effects. If mortality or emigration from the study site occurs between sampling periods, the estimator will give an unbiased but less precise estimate of $\hat{N}$ as long as the loss rate affects marked and unmarked birds equally. Higher rates of loss of marked birds, loss of marks on birds, recruitment of unmarked birds, or immigration of unmarked birds cause overestimation of $\hat{N}$. Higher loss rates of unmarked birds or higher probability of recapturing marked birds result in underestimation. If capture probabilities differ among identifiable subgroups, population sizes should be estimated separately for each subgroup. Probably the best means to ensure the validity of the closure assumptions is to complete sampling in a short interval of time and to reduce the length of time between sampling periods. Also experiments should be conducted at a time when recruitment and movement do not occur and when there is a minimum amount of mortality. Although various assumptions may be violated when population size is estimated from field data, Cowardin and Higgins (1967) found that estimates of population size based on the Lincoln-Petersen estimator were more realistic than total counts.

Experiments are often conducted in which a closed population is sampled more than two times. For these experiments, Otis et al. (1978) presented a series of models to estimate population size, and White et al. (1982) have developed a comprehensive computer program, CAPTURE, to facilitate model selection and estimation. Sampling is very similar to the two-sample Lincoln-Petersen model. Birds are captured during an initial sampling period, marked, and released. A second sample is taken, recaptures of marked birds are noted, unmarked birds are tagged, and all are released. Sampling is continued for K sampling periods. The major operational change between the two-sample and K-sample experiment is that birds must be individually marked and all recaptures must record the individual code. Individual codes are necessary because the models used to describe the recapture data generally require complete capture histories. Otis et al. (1978) also provide a test for the closure assumption, goodness-of-fit tests for each model, and a discriminant classification function to provide an objective procedure to select the appropriate model.

Assumptions required by the Otis et al. (1978) models are that (1) the population is closed, (2) marks are not lost, and (3) all marks are correctly noted. In addition to these assumptions, each model discussed by Otis et al. (1978) makes a different set of assumptions concerning variation in the probability of capture (heterogeneity, trap response or time variation). The effect of the violation of assumptions concerning capture probabilities will be different for each model. Loss of marks will cause the population size to be overestimated. As noted for the two-sample estimator, proper choice of time of year for sampling is the most practical means of ensuring closure.

For longer experiments, open population models are used to estimate population size for the K sample experiment when recruitment, mortality or movement occurs between sampling periods (Jolly 1965, Seber 1965, *also see* Cormack 1972 and Pollock et al. 1990). Under the Jolly-Seber model, population size at time period i is estimated by $\hat{N}_i$, with approximate variance $\hat{v}[\hat{N}_i]$ (Seber 1982:196–205):

$$\hat{N}_i = (N_i/M_i)M_i = \frac{n_i}{m_i} M_i \quad i = 2, 3, \ldots, K - 1 \qquad (1)$$

$$\hat{v}[\hat{N}_i] = \hat{N}_i(\hat{N}_i - n_i)\left[\frac{\hat{M}_i - m_i + R_i}{\hat{M}_i}\left(\frac{1}{r_i} - \frac{1}{R_i}\right) + \frac{1 - m_i/n_i}{m_i}\right]$$

where n_i is the number of birds captured in the ith sample, m_i is the number of marked birds captured in the ith sample, and $\hat{M}_i$ is the estimated number of marked birds in the population during the ith sample. The value $\hat{v}[\hat{N}_i]$ decreases with increasing number of recaptures (r_i), increasing proportion of marked birds in the sample (m_i/n_i), and increasing sample size ($\hat{N}_i - n_i$). Under closed population estimators, M_i is known due to the closure assumption, but in the Jolly-Seber model, M_i is not known and must be estimated. The value M_i is estimated (Seber 1982) as:

$$\hat{M}_i = \frac{R_i z_i}{r_i} + m_i \quad i = 2, 3, \ldots, K - 1 \tag{2}$$

where R_i is the number of marked birds released into the population after the ith sample, r_i is the number of marked birds released after the ith sample that are subsequently captured, and z_i is the number of birds that are captured before the ith sample, not captured during the ith sample, and captured again after the ith sample.

The open population estimators generally require the following assumptions (Seber 1982): (1) all birds in the population have the same probability of capture during the ith sample given that they are alive in the population during the ith sample, (2) all birds have the same probability of surviving from sample i to $i + 1$, (3) marked birds do not lose their marks, (4) all samples are instantaneous, and (5) losses to the population through emigration are permanent. Several reduced parameter models, that restrict capture and/or survival probabilities to be constant over all samples, have also been developed (Jolly 1982, Brownie et al. 1986). Pollock et al. (1990: 65–81) provides guidelines for designing mark-recapture studies.

If variation in capture probability among individuals within a sampling period is present and the variation persists during the study, the heterogeneity in capture probabilities will cause a negative bias in the estimation of $\hat{N}_i$ (Pollock et al. 1990). The magnitude of the bias depends on the average capture probability and the degree of variation in capture probability. Gilbert (1973) found that when the average probability of capture was greater than 50 percent, the bias in $\hat{N}_i$ resulting from unequal probability of capture was small. Moderate variation in capture probabilities among birds resulted in a fairly small bias in $\hat{N}_i$, but larger variation in capture probabilities caused large negative biases (Carothers 1973). When identifiable subgroups have large differences in probability of capture, it is best to estimate each subgroup separately.

Variation in survival among different age and sex classes is common in many species of birds. When survival probabilities are lower for young, estimates of $\hat{N}$ will have a positive bias (Manly 1970). In situations where survival differences exist between identifiable age classes of a population, models incorporating age-specificity should be used (Pollock 1981b, Stokes 1984, Brownie et al. 1986). If ages cannot be determined at marking, small differences in survival between age classes will have a negligible effect on the estimation of population size (Manly 1970). As noted earlier, sex-specific differences in survival are believed to be small for geese.

The assumptions that birds do not lose their marks and that marks have no effect on survival are important for estimating survival rates but have no influence on the estimation of population size (Arnason and Mills 1981, Pollock et al. 1990).

The assumption that sampling is instantaneous can never be strictly met, but efforts should be made to keep the sampling period short enough that mortality during the sampling interval is negligible. The assumption regarding non-permanent emigration can be important, especially for a study of survival. For studies on a flyway level, non-permanent emigration will be very small. However, for smaller-scale projects, movement can be a greater problem. The best way to restrict this problem is to conduct the estimation during a period of time when migration or smaller-scale movement will be small.

Sulzbach and Cooke (1979) found that the Jolly-Seber model provided an estimate of number of potential nesting snow geese, while visual estimates indicated the number of adults that actually nested. Nichols et al. (1981) found that similar patterns of population increase were obtained for estimates of population size from the Jolly-Seber model and from the midwinter aerial survey.

The above estimates of population size were obtained from mark-recapture data. Generally, population size cannot be estimated using mark-resight data because information is only collected for marked individuals during the sampling periods. However for geese, birds are found in large flocks which contain both marked and unmarked individuals. Population size can be estimated for these populations by recording the individual neck-band codes and the number of geese examined for neck bands. Population size is still estimated as in equation 1 but its variance is estimated (Goodman 1960) as:

$$\hat{v}[\hat{N}_i] = (\widehat{N_i/M_i})^2\,\hat{v}[\hat{M}_i] + \hat{M}_i^2\,\hat{v}[\widehat{N_i/M_i}] - \hat{v}[\hat{M}_i]\,\hat{v}[\widehat{N_i/M_i}]$$

The value $\hat{M}_i$ is estimated as in equation 2 and its variance is estimated (Seber 1982) as:

$$\hat{v}[\hat{M}_i] = (\hat{M}_i - m_i)(\hat{M}_i - m_i + R_i)\left(\frac{1}{r_i} - \frac{1}{R_i}\right)$$

The value $\hat{v}[\hat{M}_i]$ decreases with increasing number of recaptures (r_i) and increasing number of marked birds in the sample ($\hat{M}_i - m_i$).

The estimate of N_i/M_i in equation 1 is based on one sample. The estimate and the variance of the estimate can be greatly improved by sampling more than one flock. When more than one flock is sampled, N_i/M_i and its variance are estimated (Cochran 1977:150–167) as:

$$\widehat{N_i/M_i} = \frac{\sum_{j=1}^{f_i} n_{i,j}}{\sum_{j=1}^{f_i} m_{i,j}}$$

$$\hat{v}[\widehat{N_i/M_i}] = \left(1 - \frac{f_i}{F_i}\right)\left(\frac{1}{f_i}\right)\left(\frac{1}{\overline{m}_i^2}\right)\left[\frac{\sum_{j=0}^{f_i} (n_{i,j} - (\widehat{N_i/M_i})m_{i,j})^2}{f_i - 1}\right]$$

where f_i is the number of flocks sampled during the ith sample and F_i is the total number of flocks present in the survey area during the ith sample. The value $\hat{v}[\widehat{N_i/M_i}]$

decreases with increasing number of flocks sampled (f_i), increasing average number of marked birds per flock (m_i), and increasing sampling fraction (f_i/F_i). The bias of the ratio estimator is generally negligible for large samples (Cochran 1977). The number of flocks sampled should be large enough so the ratio will be nearly normally distributed and the large-scale variance formula will be valid. Generally, when the number of flocks sampled exceeds 30, the large-sample results may be used. When the number of flocks sampled is less than 30, variance will be underestimated. If F_i cannot be estimated, F_i can be assumed to be sufficiently greater than f_i such that $(1 - f_i/F_i) \cong 1$. This assumption increases $\hat{v}[\widehat{N_i/M_i}]$. If population number is being estimated for more than one region, biases will exist if marked birds move among regions between the $i - 1$ and i samples or if marked and/or unmarked birds move among regions during a sampling interval.

It is important to note that $\widehat{N_i/M_i}$ and $\hat{M}_i$ are estimated from a cohort of birds that were released or observed during the $i - 1$ sampling period. A flock of geese will often contain neck-banded geese that were not seen or released during the $i - 1$ sample. These individuals are considered to be part of the unmarked population. To ensure that useful data are collected, the individual neck-band codes for all marked birds and the number of birds examined for neck bands should be recorded for each flock encountered along the survey route.

The precision of $\hat{N}_i$ depends on the precision of $\widehat{N_i/M_i}$ and of $\hat{M}_i$. The precision of $\widehat{N_i/M_i}$ can be increased by increasing the number of flocks sampled and by increasing the number of marked birds in the population. The precision of $\hat{M}_i$ can be increased by increasing the probability of resighting marked individuals and by increasing the length of time observations are made for a sample. From estimates on Canada geese, $\hat{v}[\widehat{N_i/M_i}]$ contributes the largest amount of variation to the estimation of $\hat{v}[\hat{N}_i]$ (Hestbeck and Malecki 1989a).

Hestbeck and Malecki (1989a) used mark-resight data on Canada geese from eight states in the Atlantic Flyway to make an independent comparison of the aerial survey. During the 1987 midwinter period, the time when the maximum number of marked geese were in the flyway, the midwinter aerial survey estimates were within the 95 percent confidence levels for the regional and flyway mark-resight estimates.

Survival Rates

The probability of survival (ϕ) can be estimated using the open population models with either mark-recapture or mark-resight data (Cormack 1964, Brownie and Robson 1983, Pollock et al. 1990). The probability of surviving from sample i to $i + 1$ and its corresponding variance can be estimated from the Jolly-Seber model (Seber 1982:196–205) as:

$$\hat{\phi}_i = \frac{\hat{M}_{i+1}}{\hat{M}_i - m_i + R_i} \qquad \begin{matrix} \hat{M}_1 = m_1 = 0 \\ i = 1, 2, \ldots, K - 2 \end{matrix}$$

$$\hat{v}[\hat{\phi}_i] = \hat{\phi}_i^2 \left[\frac{(\hat{M}_{i+1} - m_{i+1})(\hat{M}_{i+1} - m_{i+1} + R_{i+1})}{(\hat{M}_{i+1})^2} \left(\frac{1}{r_{i+1}} - \frac{1}{R_{i+1}} \right) + \frac{(\hat{M}_i - m_i)}{(\hat{M}_i - m_i + R_i)} \left(\frac{1}{r_i} - \frac{1}{R_i} \right) + \frac{1 - \phi_i}{\hat{M}_{i+1}} \right]$$

where $\hat{M}$ and R are defined above. The value $\hat{v}[\hat{\phi}_i]$ decreases with increasing number of recaptures (r_i) and with increasing number of marked birds in sample i and $i + 1$ [$(\hat{M}_i - m_i)$ and $(\hat{M}_{i+1} - m_{i+1})$].

The assumptions required for the estimation of population size from the Jolly-Seber model also apply to the estimation of survival rates. However, the violation of the assumptions can have different effects. Carothers (1979) found that biases in the estimation of survival rates due to heterogeneity in probability of capture among individuals were negligible, even when the test of equal catchability revealed significant variation in capture probabilities.

As noted before, heterogeneity in survival between different age and sex classes is common. When the probability of survival is lower for young, estimates of population survival have a positive bias (Manly 1970). When variation exists between identifiable age-classes, models incorporating age-specificity should be used (Pollock 1981b, Stokes 1984, Brownie et al. 1986). If marks decrease the probability of a goose surviving, serious negative biases can result. Neck bands do not appear to significantly reduce survival for geese (Aldrich and Steenis 1955, Samuel et al. 1990). However, Ankney (1975) has reported that significantly more neck-banded female lesser snow geese starved to death than unmarked females (*also see* Raveling 1976).

Estimation of survival probabilities however is more sensitive to the assumption regarding the length of sampling and inter-sampling periods. Because sampling is assumed to be instantaneous, all mortality should occur between samples. To guarantee this, the length of the sampling period should be small compared to the length of time between sampling, and sampling should not occur during periods of high mortality such as the opening of hunting seasons.

The complements of estimated survival probabilities from mark-recapture studies contain losses due to neck-band loss and to permanent emigration from the study area. In order to provide a good estimate for survival, independent estimates for neck-band loss and permanent emigration must be made. Because neck-banded geese are double-banded with leg bands, neck-band loss can be determined by retrapping geese and checking all leg-banded geese for neck bands. The retrap data should include the original banding date, the date of retrapping, and whether the individual has a neck band. Retrapping should occur as close to the anniversary date used in the survival analysis as possible. Also neck-band retention may vary among populations so the retention rate should be estimated separately for each population. Annual retention probabilities (θ_i) are defined as the probability that a bird that is alive and still has the neck band i years after initial banding, retains the neck band from i to $i + 1$ given that the bird also survives the year. Annual retention probabilities can be estimated by using program SURVIV (White 1983). SURVIV is a general program that performs maximum likelihood estimation for multinomial models using numerical optimization. The expected number of retrapped geese with neck bands (T_i) from the number of retrapped geese banded i years previously under a general model is:

$$E[T_i] = N_i \prod_{j=0}^{i} \theta_j$$

where N_i is the number of retrapped geese banded i years previously and θ_j is the annual neck-band retention rate for the jth year. With this general model, the annual probability of neck-band retention (and loss) is modeled as a function of years after banding, but not of calendar year. Various reduced-parameter models can also be used in which the annual retention rates are constrained to be constant regardless of the number of years since banding (e.g., $\theta_i = \theta$ for all i).

If retention rates are constant, estimated survival rates and their variances can be corrected for neck-band loss (Mood et al. 1974:181, Pollock 1981b, Arnason and Mills 1981, Hestbeck and Malecki 1989b) by:

$$\hat{\phi}_i' = \frac{\hat{\phi}_i}{\hat{\theta}} + \frac{\hat{\phi}_i}{\hat{\theta}^3}\hat{v}[\hat{\theta}] \tag{3}$$

$$\hat{v}[\hat{\phi}_i'] = (\hat{\phi}_i')^2\left(\frac{\hat{v}[\hat{\phi}_i]}{\hat{\phi}_i^2} + \frac{\hat{v}[\hat{\theta}]}{\hat{\theta}^2}\right).$$

The covariance between estimated survival and retention rates is zero because retention is estimated from retrapped geese and survival is estimated from recapture or reobservation data. The value $\hat{v}[\hat{\phi}_i']$ increases when the probability of tag retention ($\hat{\theta}$) decreases and when $\hat{v}[\hat{\theta}]$ increases.

Two approaches can be used to correct survival estimates for neck-band loss when retention rates are not constant (Nichols pers. comm.). One method estimates time-specific retention rates from the retrap data using SURVIV and survival rates over each sampling interval using the standard Jolly-Seber model for each neck-banded cohort separately (*see* Loery et al. 1987). Each survival estimate over the interval i to $i + 1$ is corrected using the above formula with the time-specific retention probability for the ith time periods after initial banding. The second method uses a single model programmed with SURVIV to estimate probabilities of survival and neck-band retention by directly incorporating survival, ϕ_i, and retention, θ_i, parameters with observation and retrap data. The use of a single model within program SURVIV allows a large number of constrained or reduced-parameter models to be developed, goodness-of-fit tests to be made for each model and likelihood ratio tests to be made between models.

An indication of the importance of permanent emigration can be obtained by determining the percentage of marked geese that are recovered outside the study area. An estimate of permanent emigration rate can be obtained as one minus the quotient from the division of the Jolly-Seber survival rate corrected for neck-band loss (includes mortality and permanent emigration) by the survival rate estimated from band-recovery data (includes only mortality). Generally, permanent emigration from the study area is very small for flyway-wide studies but can be significant for smaller scale studies. As before, the bias due to permanent emigration can be reduced with proper choice of time periods.

For a comparison between band-recovery and mark-recapture experiments, survival rates were estimated for double-banded Canada geese in the mid-Atlantic, Chesapeake and Carolina regions using either band-recovery data (described above) or mark-resight data. The mark-resight estimates were obtained by the method described in Hestbeck and Malecki (1989b). The estimated annual survival rates ranged from 0.566 (0.025) to 0.756 (0.018) (Table 1). In contrast to the band-recovery estimates, mark-resight estimates of annual survival rate can be sufficiently precise to allow inferences about sources of variation in survival estimates.

Movement Rates

Movement and fidelity to wintering areas have important management implications for goose populations. During the last three decades, dramatic changes in the number of geese wintering in different regions have occurred for lesser snow geese (Dzubin 1979, Bateman et al. 1988) and for Canada geese in the Atlantic population (Trost and Malecki 1985, Hestbeck and Malecki 1989b), Mississippi Valley population (Reeves et al. 1968, Rusch et al. 1985), Eastern Prairie population (Vaught and Kirsch 1966, Humberg et al. 1985), Hi-line population (Szymczak 1975), and Rocky Mountain population (Krohn and Bizeau 1988).

Two three-sample mark-resight models were developed to estimate site fidelity and movement probabilities (Hestbeck et al. 1990). One model, MV1, appears to be equivalent to that of Arnason (1972, 1973) and is parameterized with transition and sighting probabilities. Transition probabilities, $\phi_{i,j,k}$, are defined as the probability that a bird alive and present in region j during year i survives and is present in region k during year $i + 1$. The sighting probabilities, $P_{i,j}$, are defined as the probability that a bird present in region j during year i is observed during that period. Sighting probabilities are similar to the capture probabilities of the standard Jolly-Seber model and differ only in that they are defined for region j. Transition probabilities are similar to Jolly-Seber survival probabilities but differ in specifying location of the goose at the beginning (region j) and ending (region k) of the transition period (i to $i + 1$). Movement in MV1 is described by a first order Markov chain, i.e., movement between two consecutive sampling periods depends only on the location of a bird in the prior sampling period.

The assumptions required by model MV1 are similar to those required by the standard Jolly-Seber model (Seber 1982, Pollock et al. 1990): (1) time- and region-specific sighting and transition probabilities are the same for all marked birds found in a particular region and in a particular sampling period, (2) birds behave independently with respect to sighting probability, survival and movement, and (3) any birds moving out of the sampled regions remain outside.

A more general model, MV2, was also developed which incorporated "tradition" or memory of previous wintering regions into a probabilistic model. In this model, movement was described by a second order stochastic process such that the transition probabilities, $\phi_{i+1,j,k}$, depend on the location not only at $i + 1$ but also the location during the previous year at i. Specifically, the transition probability from location j at $i + 1$ to location k at $i + 2$ was allowed to differ for geese that were located in region k at time $i(\phi'_{i+1,j,k})$ versus geese that were not located at k during time i $(\phi^*_{i+1,j,k})$.

The assumptions for model MV2 are similar to those for model MV1 except that assumption one is modified to allow that all marked birds with the $\phi'_{i+1,j,k}$ or $\phi^*_{i+1,j,k}$ transition probabilities have the same probability of moving from region j to k given that the bird was either inside or outside of region j at time i and was in region j at time $i + 1$.

Closed-form estimators were not derived (Arnason [1973] however derived moment estimators for MV1). Estimates of transition and sighting probabilities were obtained using maximum likelihood estimates under each model using program SURVIV. Goodness-of-fit tests for each model and a likelihood ratio test between models were conducted using SURVIV.

The transition probabilities that were estimated actually represent products of movement and survival probabilities and can be written as:

$$\phi_{i,j,k} = S_{i,j}\ \psi_{i,j,k}, \tag{4}$$

where $S_{i,j}$ represents the probability that a goose alive during time i in region j survives (does not die or permanently emigrate) until time $i + 1$, and $\psi_{i,j,k}$ denotes the probability that a goose in region j during time i moves to region k at time $i + 1$ given that the goose survives from i to $i + 1$. Because $\Sigma_{k=1}^{3}\ \psi_{i,j,k} = 1$, we can write an identity for $\psi_{i,j,k}$ as:

$$\psi_{i,j,k} = \frac{S_{i,j}\ \psi_{i,j,k}}{S_{i,j}\left(\sum_{k=1}^{3} \psi_{i,j,k}\right)}. \tag{5}$$

An estimator for $\psi_{i,j,k}$ can be obtained using eqs. 4 and 5 as:

$$\hat{\psi}_{i,j,k} = \frac{\hat{\phi}_{i,j,k}}{\sum_{k=1}^{3} \hat{\phi}_{i,j,k}}. \tag{6}$$

Because the estimated variances and covariances for $\hat{\phi}_{i,j,k}$ will not be zero, the modified estimator and associated variance presented in Hestbeck et al. (1990) should be used to estimate $\hat{\psi}_{i,j,k}$ instead of equation 6.

Model MV2, which incorporated "tradition" or memory of previous wintering regions, fit data on Canada geese better than model MV1 which assumed that a first order Markov chain described movement among regions (Hestbeck et al. 1990). Changes in estimated probabilities of moving between years corresponded to changes in winter harshness. The mean annual probability of remaining in the same region for two successive winters, used as a measure of site fidelity, and the estimated mean probability of moving among regions indicated that Canada geese have a high probability of moving to and remaining in the Chesapeake region. Also considerable numbers of geese from the Carolinas appeared to be wintering in more northerly locations ("short-stopped") in subsequent winters.

Hestbeck et al. (1990) used a two-step process to estimate movement probabilities, first estimating $\phi_{i,j,k}$ using program SURVIV and then estimating $\phi_{i,j,k}$ as in equation 6. Attempts were also made to directly estimate movement probabilities by parameterizing models with $S_{i,j}$ and $\psi_{i,j,k}$ (rather than $\phi_{i,j,k}$) using the constraint that $\Sigma\,\psi_{i,j,k} = 1$. Under this model, useful estimates for the Canada goose data could not be obtained using program SURVIV. However, this approach holds promise and will be used in the future.

Discussion and Summary

Band-recovery and mark-recapture data provide useful information about population distributions in time and space and allow estimates of several demographic parameters which help to explain changes in population size (Table 2). The tradeoff between using leg or neck bands centers on the type and quality of information needed and the cost of the information. The information available from leg and neck

Table 2. Comparison of inferences available from mark-capture (resight) data for neck-banded birds or from band-recovery data for leg-banded birds.

Mark-capture	Band-recovery
1. More observer error. More data editing required.	1. Less observer error. Less data editing.
2. Observer network required.	2. No network of project observers needed.
3. More information per banded bird.	3. Less information per banded bird.
4. Estimate breeding and wintering ground affiliations and migration corridors.	4. Estimate breeding and wintering ground affiliations and migration corridors.
5. Can estimate distribution and derivation of harvest from double-banded birds.	5. Can estimate distribution and derivation of harvest.
6. Can estimate migration chronology for local area or given population.	6. Can estimate migration chronology for larger area and for continental populations.
7. Can estimate population size.	7. Can obtain an idea of population size if have data from harvest survey.
8. Can estimate survival rates. $(1 - \hat{S})$ = Mortality + Emigration + Tag Loss Tag loss must be estimated. Estimates are more precise per banded bird. Seasonal survival rates can be estimated.	8. Can estimate survival rates. $(1 - \hat{S})$ = Mortality Tag loss is negligible. Estimates are less precise per banded bird. Seasonal survival rates cannot be estimated without a special banding program.
9. Can estimate recovery rate for locally observed and double-banded population.	9. Can estimate recovery rate for banded population.
10. Can estimate movement probabilities.	10. Cannot estimate movement probabilities but can get a general idea of movement.

bands differs, and consequently the inferences drawn from leg- and neck-band data also differ. Leg-band programs are easier to conduct, but low recovery rates for geese limit available data and sampling by hunter returns can be unsatisfactory. Neck-band programs result in more information per banded bird. However, neck bands may cause behavioral changes or death through icing; an observer network is required to collect data; the error rate of observation may be higher; and the researcher must independently collect, process and maintain the data.

Breeding and wintering ground affiliations as well as migration corridors can be defined from both data sources; however, neck band programs provide more information. The distribution and derivation of harvest can be estimated for both neck- and leg-banded birds because neck-banded birds also carry a leg band. Migration chronology can be estimated from both data sources. Neck-band data provide the better estimate because of more information, and sampling can occur as birds arrive at staging or wintering areas. An idea of movement and population size (harvest survey also needed) can be obtained from band-recovery data, but precise estimates can only be made from mark-recapture data. Recovery rates can be estimated for the entire banded population using band-recovery data. Using data from neck-banded geese, recovery rates can be estimated for a group of birds that are observed in a given harvest area before the hunting season. Survival rates can be estimated from band-recovery data but in situations where geese exhibit low recovery rates, inferences about annual survival estimates will never be very strong. The most that can be hoped for using band-recovery data with low recovery rates is a relatively precise estimate for average annual survival over a number of years. Survival rates, estimated from mark-recapture data can be precise enough to allow inferences about sources of variation in annual survival rates; however, independent estimates of tag loss and of emigration from the sampling area are required.

In essence, leg-band data provide information at time of banding and recovery. Because neck-banded birds are also banded with leg bands, information is collected at time of banding and recovery, plus from observations occurring during the life of the individual. Only radio telemetry provides more information per marked bird. With little observer effort, the information obtained and inferences possible from neck-banded birds are similar to the information and inferences available from leg-banded birds. With a large observer effort, the information and inferences available from neck-banded birds are similar to those available from radio-telemetry data.

Neck bands can provide more information, but the cost of maintaining an observer network and of managing the data can exceed the cost of leg banding more geese. The cost of a leg-band study results primarily from the costs of banding. Costs associated with banding range from $13–34/bird on the northern breeding grounds, from $13–24/bird on the breeding grounds in the United States, and from $6–54/bird on winter grounds. Sampling occurs through the harvest, and is therefore widespread and inexpensive. The costs associated with processing and maintaining the data are covered by the Bird Banding Laboratory, Laurel, Maryland. The cost of a neck-band study results from the costs associated with banding, the observer network, and recording, processing and maintaining the data. Costs associated with observing geese range from $61–88/day/observer. Costs associated with processing and maintaining the data are approximately $70,000–75,000 per flyway. Sampling is generally conducted by project observers, tends to be more localized and is more expensive. The cost of neck banding can be somewhat reduced because the required number of banded individuals can be smaller.

Due to the recent advances in the analysis of leg- and neck-band data, future research programs should be designed to address specific questions. The tradeoff between using leg or neck bands depends on the type and quality of information required and the cost of the information. If the general distribution of a population is desired, a study using leg bands could provide the necessary information for a relatively low cost. If a researcher wishes to test hypotheses about annual variation in survival rates, greater levels of precision are necessary, and a neck-band study would be recommended. For neck-band studies, banding and observing should be restricted to specific time periods determined by the design to maximize the information obtained and minimize the cost.

For example, a study is proposed for the Atlantic Flyway in which the migrant and resident subpopulation of Canada geese can be managed and monitored separately through a program of neck banding during the summer and post-harvest, and observing during summer, pre-harvest and post-harvest. This experimental design allows the estimation of (1) survival and movement rates to be estimated over experimental resident goose hunting seasons, the traditional fall-winter hunting season, and nonharvest periods for the migrant and resident subpopulations; (2) the number of residents in the fall and midwinter periods; (3) the proportion of residents in the midwinter population (with aerial survey); and (4) the recovery rate for a cohort of geese observed in a particular harvest area before the hunting season. With this information, changes in harvest regulations can be related to changes in recovery rates, and also to changes in survival and movement rates over the harvest period.

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Needs, Capabilities and Prospects for the Future of Goose Management in North America

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Listening to these excellent presentations that covered various aspects of goose management of some 30 identified populations of geese in North America, a very familiar and harmonious theme emerges. This theme is signaling the direction that we will take in the management of geese in the 1990s. One of the most difficult tasks of managing any migratory species is to achieve a compromising blend of the multitudinous desires voiced by state, provincial and federal participants. With few exceptions the authors of these papers have identified similar population and management needs for goose populations. With this consistency of purpose and management direction, along with a strong resource base, we will move through the 1990s with a progressive goose management program.

It would be best to summarize the information presented to us on population status, management goals, problems, harvest objectives, etc., on a species-by-species basis.

Looking at Snow Geese

Populations of lesser and greater snow geese all appear to be strong numerically. These populations continue to provide liberal harvest with the potential of extending harvest opportunity. A major recommendation was to increase the snow goose harvest, especially of the mid-continent and greater snow goose populations.

In order to manage properly the individual populations of snow geese we need to establish accurate periodic breeding ground surveys of specific flocks to access population status. Also, marking by banding or neck collaring is necessary to provide data on migration routes, migration chronology, wintering areas and survival rates. The third need is an improved harvest survey.

Problems identified that need investigation are disease and the impact high goose populations are having on breeding colony and wintering habitat.

The need for cooperative management via the Arctic Goose Joint Venture was strongly voiced.

White-fronted Geese

White-fronted geese of the western mid-continent population are decreasing while the eastern mid-continent population is increasing. Pacific Flyway white-fronts are below population goals, but management programs are in place to ensure that population increases occur. White-fronts are one species that need close monitoring and demonstrate a strong case for reliable breeding grounds surveys, marking programs and harvest surveys.

The need for making priorities to manage Arctic nesting geese is evident and the Arctic Goose Joint Venture is a willing vehicle.

Brant

Over the years, both Atlantic and Pacific brant populations have shown the results from adverse weather factors on the breeding and wintering grounds and heavy harvest. The historic view shows brant populations have been well managed and when population declines occurred, regulations were put in place to allow population protection. Both the Atlantic and Pacific flyways have demonstrated their ability to manage these populations, and more reliable population and harvest data would only enhance their ability.

Impacts on brant habitat, such as hydro-electric development projects, are the major concern for the future of brant.

Canada Geese

Canada goose populations, with few exceptions, are quite healthy. Most populations meet or exceed objectives, and persistent cooperative management programs are in place to ensure this success. Through harvest restrictions, area closures, delayed seasons, breeding and production surveys, marking programs and management on the wintering ground, the states, provinces, Canadian Wildlife Service, U.S. Fish and Wildlife Service and the people these organizations serve have made great strides in the successful management of Canada geese across North America.

While Canada goose populations are faring well, the needs for accurate breeding ground surveys, banding and neck collaring programs and better harvest surveys have been mentioned repeatedly. These needs are deemed paramount to the continued sound management of Canada geese.

The two most serious problems identified, outside the need for more precise data, are geese wintering north of their traditional wintering grounds and the mixing of populations on the breeding grounds, migration and wintering areas. These two problems greatly complicate the management of this important resource. Other problems seen as inhibiting Canada goose management are ability to regulate harvest of individual populations, Native claims for Arctic nesting geese, increasing local giant Canada goose populations, disease and habitat changes.

It is obvious, from our speakers' remarks, that we have been quite successful managing goose populations in spite of confronting difficulties. Snow goose and many Canada goose populations are near or at all time high numbers. Atlantic Brant, the eastern mid-continent and Pacific white-fronted geese are increasing. Pacific black brant are maintaining their numbers. The dusky Canada goose, crackling Canada goose, Aleutian goose and emperor geese have declined, but through management efforts like area closures in California, other harvest restrictions, the Hooper Bay Agreement and the 1985 Yukon-Kuskokwin Delta Goose Management Plan, populations are responding. Cooperative plans of this nature point the way to the future.

It is indeed encouraging to see what has been accomplished with the endangered Aleutian goose. Management efforts in the Pacific Flyway have increased the population of that species to the point of giving consideration to downlisting from endangered to threatened.

The Mississippi Valley population of Canada geese is at an all time high, demonstrating that difficult management decisions can be made in an atmosphere of cooperation. The Atlantic Canada goose population has slipped recently, but past efforts have demonstrated the Atlantic Flyway's ability to manage this large population of geese. The Tennessee Valley and the Eastern Prairie populations of Canada geese are also doing well. Canada geese in the Central Flyway, such as the hi-line and shortgrass prairie populations, have shown increases. Giant Canada geese are increasing all across the United States and Canada and provide another example of successful management.

All these examples point to the fact that we have the knowledge, ability and dedication to manage goose populations in spite of adversities.

The future holds numerous challenges and the 1990s will not be the doldrums. The real challenges will be to manage these goose populations to provide the opportunities people have recently become accustomed to. Management will be far more difficult than closing large areas to hunting or restricting regulations which result in observable success. We will find it more difficult to make regulation and habitat adjustments on a more delicate basis. Neither the root of the problem, nor the results of our work will be as evident as in the past. This management will require a large and more accurate data base. Of 30 goose populations, we have 12 populations with significant population data, 10 with partial data and 8 with little or no data.

We must address population mixing on the breeding grounds and on migration and wintering areas. This is imperative if we are going to maintain certain populations of geese and at the same time exploit recreational opportunity of others. As pointed out in the Pacific Flyway, we may have to manage as one population or manage for the worse-case scenario for the population needing protection. This will not meet with overall approval from the public, but in extreme cases we may have to do just that. In other cases, we will need to make restrictions in specific areas for specific purposes rather than require across-the-board harvest regulations.

Geese wintering north of their traditional areas or delaying their migration by lingering at more northern locations will continue to create management nightmares. It will require hard decisions if we decide to move these birds southward without seriously reducing the population.

The one option for states that no longer winter significant numbers of Canada geese is to provide large refuges and develop local flocks that will provide some hunting and at the same time attract and protect those migrating birds that do move into the area. While this option may not be the most desirable, in some cases it may be our only one.

Habitat alterations caused by agriculture, increasing human population, fossil fuel and hydro-electric exploration and development remain ominous on the horizon of the '90s.

To address some of these problems we will need to exploit the new methodology for estimating population parameters. To do this we must collect data sets of the magnitude and accuracy to fit new models. Leg banding will still be necessary for many populations where money and manpower are limited. Color marking with neck bands can provide more information per banded bird and provide immediate understanding of migration and wintering area affiliation; however, it may be more costly of manpower to collect and manage the data. Neck banding provides us the opportunity to collect very important information but it will by necessity need to be restricted to specific instances under well-defined objectives.

The future requires expanded cooperation between Canada, United States and Mexico. Priorities will need to be made in order to address the most pressing problems with the limited funds available. The Arctic Goose Joint Venture provides the vehicle that will enhance input and cooperation of the various governing entities and allow prioritizing of projects to obtain the needed information on arctic nesting geese. It will be important to resolve the issues concerning native claims and subsistence if we are to work cooperatively in the arctic.

The consistent theme that we mentioned earlier is that we have exhibited our ability to manage goose populations the last 20 years, but to continue this level of success and make the necessary decisions, we will need more precise information. Goose management of the 1990s mandates the following:

1. Better define goose populations in relation to breeding areas, migration routes and wintering areas.
2. Develop operational breeding ground surveys on an annual or periodic basis to provide accurate information on the status of individual populations.
3. Expand and develop production surveys to more accurately access annual recruitment.
4. Develop a goose harvest survey that provides accuracy of harvest by population units.
5. Provide a banding or marking program on priority populations.

The importance of these five priorities have been clearly pointed out and the responsibility to meet future challenges calls for action by the U.S. Fish and Wildlife Service, Canadian Wildlife Service, provinces and states.

Special Session 8. *Challenges in International Resource Conservation*

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International Resource Conservation: Where's the Challenge?

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This year marks the twentieth anniversary of Earth Day, which was a historical moment for natural resource conservation and environmental consciousness in North America. Despite the international implications of the name, "Earth Day," the activities and celebrations largely remained a North American phenomenon. Thomas (1982) characterized the late 1960s and early 1970s as a period of conceptual revolution resulting in some of the most important environmental legislation the world has seen. Based upon recent developments in the international arena, I believe the late 1980s and early 1990s will represent a similar revolution on an international scale. Although North American and other developed countries have been involved in international conservation for many years (examples include the Migratory Bird Treaty Act, the Convention on International Trade in Endangered Species and the Marine Mammal Act), the pace of this involvement has accelerated in the past few years.

There are rapidly growing concerns over international resource issues as evidenced by the frequency of articles in scientific journals, popular magazines, newspapers, and documentary films and radio programs. Global warming has become a major issue discussed at all levels of society in developed countries, and at many levels in developing countries. This issue is just now beginning to receive the level of recognition that it deserves, with an international conference to develop an international treaty scheduled for next fall. Maintenance of biological diversity has become a major concern of land management agencies (Salwasser and Tappeiner 1981, Scott et al. 1987) as well as a primary issue for professional societies, the U.S. Congress and development agencies (Wilson 1985, Shaffer and Saterson 1987, U.S. Congress, Office of Technological Assessment 1987). Financial institutions that aid developing countries have recently developed an environmental consciousness that will moderate unconstrained development projects (Goodland 1987, Norse 1987). The U.S. ban on ivory trade (Hallagan 1990) is another example of increasing involvement of the U.S. Congress in international resource conservation. Debt swaps represent one of the most far-reaching conservation and development-oriented programs going. The U.S. Congress is exploring other economic incentives for financing international conservation efforts (Kasten 1990).

Thus, in the past few years, we have seen significant changes in how the world as a whole views resource conservation. Despite these changing perspectives and recent developments, I am not overly optimistic that 20 years from now we won't be saying that this was too little, too late. A look back at our conceptual revolution might help guide us into this new era of environmental awareness. We have seen a marked improvement in air quality throughout much of the U.S. However, acid rain, a dark cloud visible on the first Earth Day, is no longer on the horizon, but directly overhead. Rather than acting, we keep hoping the weather will change. Water quality as well has improved remarkably, but again these improvements are balanced by water pollution problems as the result of toxic waste, and runoff from our agricultural production. Didn't Rachel Carson (1962) warn us about this? Throughout this period of environmental awareness in the U.S. our wetlands have continued to be drained. Now we have a policy statement from our president calling for "no net loss of wetlands" and at the same time we see changing definitions of wetlands—and the draining continues. We call upon developing countries to reduce the rate of deforestation in tropical rainforests. These governments rightfully point to the determination with which we are eliminating the last vestiges of old growth forest in this country.

I could go on, but there is no reason to belabor the point. We have done a lot toward improving environmental quality and resource conservation in this country. However, we still have much to do, and the large-scale problems have proven to be especially difficult for us to deal with. This does not bode well for our international conservation prospects, nor for our own long-range sustainability of a strong, diverse and viable natural resource base. This, I believe, is the real challenge in international resource conservation; not doing something, but doing enough. We must insure that in the future we are not faced with ecological disaster relief on a scale that we can neither afford nor have the technological ability to address.

We face three major problems in confronting international resource issues: (1) coordination and teamwork; (2) integrating our efforts in the socio-political and economic framework within which these issues must be addressed; and (3) reducing provincialism. These issues are interrelated. Working together for a combined effort is a difficult challenge for the many scientific professions concerned about resource conservation. However, until we coalesce into a body of professionals working toward a common goal of wise resource sustainability and use, we will lack the intellectual, economic, social and political mass required to effect meaningful change. The recent debate among wildlifers about the relationship with, and divergence from, the newly formed Society for Conservation Biology (Anonymous 1989, Bolen 1989, Edwards 1989, Noss 1989, Wagner 1989) is a disturbing indication that our efforts towards international resource conservation may be diluted due to intersocietal competition. Because of the interdisciplinary nature of national and international resource issues, we will need all the help we can get. Therefore, not only The Wildlife Society and the Society for Conservation Biology, but the Society for Range Management, Society of American Foresters, the Ecological Society, other professional societies as well as other nonmember professionals, must desegregate and work together toward common goals.

Another problem with provincialism lies in our emphasis as a profession on solving local issues. Many people argue that we must take care of the problems in our own backyard before we address those in other areas. There is some validity to this argument. As I mentioned earlier, we set a poor example of preserving tropical rainforests as long as we are hell-bent on short-term economic benefits and continue to eliminate old growth forests in our own country. With respect to these forests, our export of un-milled logs is strikingly similar to resource exploitation in developing countries. A country that produces over 25 percent of the world's hydrocarbons has little right to point its ecologically-conscious finger. We do have serious environmental problems here, but solving these problems must be concurrent with, not a prerequisite to, attacking issues globally. Many of us have jobs that are local or regional in scope, but that does not preclude us from practicing the concept "think globally, act locally." We are all aware of the immense effort required to motivate the American public sufficiently to cause even an environmentally aware Congress and administration to act responsibly within our own borders. I can only surmise that a much greater effort will be needed to jump-start and sustain a global conservation effort. Local, regional, and national natural resource agencies and organizations have important roles to play in motivating the public. Most of these agencies and organizations have well-organized public education programs, yet little emphasis is placed on global issues. I believe that agencies such as state fish and game departments or the Cooperative Extension System could and should play a major role in notifying and helping the American public understand the consequences. There are very few local resource issues these days where it would not be appropriate to integrate global concerns with public education efforts.

Those local and regional resource professionals who still believe that they have no business discussing international problems would do well to consider the effectiveness of their programs as our local resources erode because of international environmental degradation. A couple of brief examples should be sufficient to demonstrate our peril.

Nongame programs have become increasingly important both locally and nationally as our publics become more involved in natural resource issues. Deforestation in Latin America threatens the winter habitats of many of our migratory bird species, and has the potential to cause large-scale population declines. Because of the proximity rule of public complaint, local natural resource agencies will most likely catch the flack as the public recognizes these declines.

Global climate change offers even more insidious potential for disrupting business as usual in natural resource agencies. What is likely to be the impact on our big game and furbearer management programs in the northern tier of the United States as the boreal forests retreat because of global warming? What about the opportunity for waterfowl hunting in coastal areas as water levels rise? Imagine the few habitat models we have been able to validate becoming obsolete over time because of changing plant communities. Those of us who refuse to heed these warnings would do well to study rats—they may be the big game of the future!

Scientists will not be enough; as Deshmukh (1989) points out, successful resource conservation on an international scale will require creative multidisciplinary solutions. These solutions must involve economists, sociologists, biologists, land managers and a host of other professionals, as well as politicians at all levels. Successful international resource conservation will require careful weaving of technology and scientific knowledge through a complex matrix of cultural, social, economic and political forces. Trained as scientists, managers, or administrators in our natural resource colleges, we are poorly prepared to meet this challenge.

In closing, I would like to say that there is smoke everywhere. Many people are beginning to see the flames. However, we have yet to form and train a well organized fire department. The success of this fire department will depend on all of us becoming volunteers. Thirty years from now, on the 50th anniversary of Earth Day, let's not look back and say we should have. . . . Let's take up the challenge today.

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International Resource Conservation: Thoughts on the Challenge

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Key Terms and Concepts

A joke of sorts has been circulating among conservationists: General Secretary Gorbachev asked God whether there would ever by capitalism in the Soviet Union and was told: ''Yes, but not in your lifetime.'' President Reagan asked God whether there would ever be communism in the United States and got the same answer. Then President Sarney asked God whether Brazil would ever pay off its debts and God replied: ''Yes, but not in My lifetime.'' If you can figure out who the joke is on, you win 64,000 ha of Amazonian rangeland.

At the root of this joke is a fundamental element in the challenge to international conservation. To be able to respond to the challenge we must comprehend it in its full dimensions, and a first step is to understand the basic terms involved. Although they are everyday, household words, when used to describe conservation they are subject to grave misconceptions. The key terms to define are ''international,'' ''resource'' and ''conservation''; two of these are relatively simple—the third is a clue to root problems.

What is ''conservation,'' or as it is more specifically called: ''Biological conservation?'' It is all too often thought to be a discipline for socially-minded ecologists and wildlife managers—a specialized kind of field biology that somehow takes Man into account: after all, the professionals most vocal about biological conservation are ecologists, field biologists and wildlife managers. This perception of conservation has resulted in very frustrated field biologists, but more importantly, it has retarded the conservation of natural resources to an untold degree. Biological conservation is *not* biology. Basic biological information is fundamental for sound conservation practices, but that does not give biologists the last say. Biological conservation is a human activity: initiated, oriented, directed, executed, impeded and, in the end, evaluated by humans. In a word, conservation is a sociopolitical endeavor—nothing less.

The *Oxford Dictionary of Natural History* (Allaby 1985:158) defines biological conservation as: ''Active management to ensure the survival of the maximum diversity of species, and the maintenance of genetic variety within species. The term also implies the maintenance of biosphere functions, e.g., biogeochemical cycling, without which the basic resources for life would be lost. Biological conservation embraces the concept of long-term sustained resource use or sustained yield from the biosphere, which may conflict with species conservation in some circumstances. Conservation of species and biological processes probably is unlikely to succeed without simultaneous conservation of abiotic resources.''

There are terms fundamental to this definition which invite an endless series of semantic discussions (e.g., ''management'' and ''sustained use''); and clearly various subjective, yet critical, judgments are called for. However, from the above definition the basic idea of biological conservation is clear, although the details are a certain source of perpetual debate.

"Resource," our second key term, can be defined as any object which has utility; the concept includes nontangibles such as biological processes or "ecosystem (or environmental) services" (Erlich 1985, Ledec and Goodland 1988). Furthermore, a resource can be unexploited in the physical sense, yet appreciated, or availed of, in a cultural, emotional, intellectual or religious manner, although conservationists often abrogate or ignore this fact (Naess 1986, Bell 1987, Clay 1988, Matowanyika 1989).

The third term which is fundamental to understanding our challenge is "international." Simply, this refers to any phenomenon occurring between nations, and we can interpret "nation" as the territory, or inhabitants, controlled by a sovereign government. For example, the United States of America is a nation: "One Nation under God." The United States of México is also a nation, and so are the republics of Guatemala, Nicaragua, Panamá and Perú, as well as India, Pakistan, the People's Republic of China (PRC), Ethiopia, Somalia and Kenya. All told, the United Nations includes some 150 member nations. But, defining the limits of sovereignty, or even what it comprises, is not simple.

Within the territorial limits of the USA are dozens of Indian reservations; one of the best known is in the Southwest, where the inhabitants are known as the "Navajo Nation." There are certain considerations reflecting sovereignty for each of the reservations: certain laws and access to the land are controlled by the relevant tribe. The island of Niihau, in the Hawaiian Archipelago, has been off limits to all but a tiny fraction of the citizens of the USA—only people with Hawaiian ancestry have been allowed on the island. In this sense, the USA is not one, but several, nations, where there are subsets of territorial sovereignty controlled by subsets of the population.

Take México: of the 32 states in the Republic, several have interstate border disputes—the territorial boundaries, or geographic limits of sovereignty, between states have not been resolved. It is important to appreciate that the Mexican states have considerable autonomy and voice as to what happens within the state territory, so a border dispute is not just a pedantic point. (People in the USA should not forget that problems between state boundaries were common in the USA during the last century).

Another issue in México involves not the physical limits, but the concept, of sovereignty. For example, the Yucatán Peninsula, an area geologically and faunistically distinct from the rest of the country, is inhabited mainly by a people with unique racial features and language—the Maya. Many natives of Yucatán think of México as a foreign country, yet they consider certain parts of Guatemala as the same country.

In Guatemala, the people of El Petén consider themselves as apart from those of the highlands and rest of the country; indeed, the Petén shares the same geologic, faunistic and cultural history as does the Yucatán. At another level, the government and many people of Guatemala maintain that Belize (formerly British Honduras) is part of Guatemala. If there were to be a reestablishment of the Mayan Nation, it would include the Yucatán, Petén, Belize and parts of Honduras and El Salvador.

Nicaragua is a country that some people in the USA wish would disappear, but few of them realize that aside from the Contra-Sandinista-Somocista war is a much older, more critical conflict. The Ramas, Sumus and especially Miskito peoples of the Caribbean coast have for centuries contested Managuan domination—be it in the hands of Somoza or Ortega (Conzemius 1932, B. Nietschmann pers. comm.).

A more general question also concerns Nicaragua: who dictates what happens in the country (i.e., where is the sovereign power)? Aside from arguments of democratic representation by the populace, it is quite clear that it is not solely people of Nicaragua who determine what happens in Nicaraguan territory—Havana, Moscow and Washington have had deciding voices.

In Panamá is a similar situation. However, the Kuna peoples legally control the whole of Kuna Yala, their homeland—nearly 4 percent of Panamanian territory (and almost one quarter of the total area in the country that is part of wildlands management areas) (Clay 1988:66, Ledec and Goodland 1988:80, Reid et al. 1988:12). They do not think of themselves as Panamanian—but as Kuna.

The dictatorship of General Noriega, and subsequent invasion of Panamá by US troops, also raise basic questions about sovereignty and control of territory. Corrupt, autocratic despots are hardly justifiable as heads of sovereign states. On the other hand, one sovereign state, the US, intervened within the territory of another sovereign state, Panamá, and purposefully changed the sovereign power. From a Latin American perspective, these types of violation of sovereignty are threateningly common, whether they are related to economic or military pressures (Galeano 1973, Barry et al. 1983, Schlesinger and Kinzer 1983, Barry and Preusch 1986).

Perú is thought of as a single nation, but for nearly a decade the Sendero Luminoso has been waging a civil war and, by means of a well-equipped army, controls vast areas of the highlands. Perú does not function as a single, sovereign nation.

Old world examples of complications in sovereign control are just as remarkable: India, Pakistan and the PRC are all involved in foreboding border disputes, and in addition there are serious separatist movements in all of these nations. Examples of civil wars or separatist movements in Africa (e.g., Eritrea in Ethiopia) are just as striking. Frequently there is strife where a modern day "national" border dismembers what was formerly a cultural group (e.g., the Somali peoples of Kenya and Somalia, and the Galla peoples of Somalia and Ethiopia). On the other hand, where culturally diverse groups are consolidated within one area there is repeatedly social unrest; separatist movements are clear examples of this phenomenon (e.g., the Basques in Spain and "Kalisthan" in India).

All told, today there are scores of countries with serious cases of armed insurrection, official repression, civil war or separatist activities (Anonymous 1987). This represents a remarkably very high percentage of the total number of modern nations.

In developed countries, these forms of strife are often thought of as being rare in the modern world, or at least symptomatic of immature, underdeveloped nations of the Third World. We tend to forget that there are serious separatist movements in Europe (Spain and the United Kingdom to name just two), and that territorial conflict is not uncommon in the First World (e.g., the two Germanys, the UK and Argentina, and France and the Comores).

The phenomenon of variance between government and territory (or power base and resource base) is truly global, and involves peoples of all kinds, despite factors such as race, creed, sex, age or national origin. This conflict was simply summed up by Tatanka Wotanka ("Sitting Bull") when, referring to the wanton destruction of plains resources by colonists of European descent, he said: "This government is giving my country a bad name."

These have been examples of problems within nations, or between governments and the territories they rule. But this is only one side of the issue; another involves entities that are larger than any single government—multinational corporations and other enterprises. These organizations, and the people who control them, have frequently shown themselves to be outside the reach of individual governments, be they merchants of bananas, beverages, toothpaste, petroleum, dollars, pesticides or cocaine.

Multinational and binational organizations that are "official," recognized and supported by participating governments, have a history of behaving independently of the opinions and needs of local populations, and even acting without full respect to local and national laws. For example, the World Bank—"owned by 150 developed and developing member nations"—and by International Monetary Fund have been severely criticized for activities which they have supported and/or initiated, without adequate consideration of local environmental problems (Ledec and Goodland 1988). The World Bank has approved projects despite a lack of prerequisite biological and technical information, or worse has sanctioned projects despite information which clearly disaffirms their decisions to do so. In certain instances their judgments have been questioned in the host countries on grounds of legality—to say nothing of ethics (Anonymous 1988, Reid et al. 1988, Durning 1989).

It is important to realize that many of these official organizations have clear policy statements which favor economic development consistent with local representation and conservation practices. For example the wildlands policy of the World Bank is remarkably thorough (Goodland 1987, Ledec and Goodland 1988). However, it is argued that while excellent in theory, these policies are frequently not put into practice, and major concerns have been accessibility of planning and environmental information and inclusion of democratic processes for local peoples in the decision-making procedures (Stokes 1978, Anon. 1988, Reid et al. 1988, Durning 1989).

If these official multinational organizations show a glaring lack of concern for local opinions and needs (i.e., the elements of sovereignty), clearly the attitudes and actions of commercial multinational corporations can be no better, for their primary concern is profit and primary responsibility to their share holders. Criticism of multinational activities in the developing world is widespread, for there is a prevailing tendency to reap short-term gain for a few people at the cost of many people, by exploiting legal and economic differences in diverse sovereign states. There is also a long and tortuous history of private multinational companies influencing (even undermining) sovereign governments, either directly or via powerful connections in governments of industrialized nations (Galeano 1973, Barry et al. 1983, Schlesinger and Kinzer 1983, Barry and Preusch 1986).

Half a century ago, Franklin D. Roosevelt expressed concern for this situation when he said: "Concentration of economic power in all-embracing corporations . . . represents private enterprise becoming a kind of private government which is a power unto itself—a regimentation of other people's money [resources] and other people's lives."

Indeed, it is not only the profit-oriented commercial banks and multinational corporations which have a long history of exploiting developing countries and stretching the conceptual and functional limits of sovereignty. Even charitable relief organizations have a track record of intervening in the issues of other nations, often without due consideration of the local issues and needs; the effects on the population and long-term resource utilization have regularly been disastrous as a result (Wijkman and Timberlake 1984).

What is the point to this rampage through world history and current world affairs? Simply that it is not so easy to determine who uses, controls or determines the use of the resources of an area. The inhabitants of a territory, or even "the government in power," may not be the deciding factor in establishing patterns of resource utilization in the area. Sovereignty is basic to conservation, for obviously those who use and control natural resources must be involved in their conservation. But in reality the concept of sovereignty is incredibly complex because of the intricacies of national and international relations. It is unrealistic, and irresponsible, to simply assume that the sovereign power of a resource can be looked up in an atlas. Furthermore, there are strong arguments against turning over sole responsibility for biological conservation to sovereign governments (Salwasser 1987).

International Resource Conservation and Human Affairs

In the spectrum of human affairs, there are many facets which at first seem unrelated, or at least distant, to resource conservation. However, if conservation is a sociopolitical activity, then the levels of complexity will only increase when it is in an international context, and as a result the variety of impinging factors is almost infinite. Some of the more conspicuous points are: environmental refugees, human disasters, poverty, socioeconomic development, foreign aid, foreign debt and human rights.

A persuasive, yet often ignored, argument showing the interlinking between the status of the environment and human behavior is Jacobson's (1988) thesis on "environmental refugees," people who flee from conditions of environmental degradation. Vast areas of the world are being despoiled by Man's activities, be they high-tech (high-risk) technologies or unsustainable land-use practices of the lowest classes of society. The barometer of this predicament is that, although not officially recognized by governments, in 1986 there were estimated to have been at least 10 million people whose lives had been uprooted by environmental deterioration (Jacobson 1988:6).

To the laity of the USA this problem may seem rather remote and exaggerated, yet the effect of environmental-agricultural degradation in the Great Plains during the 1930s and the massive westward migrations of erstwhile farmers shows that the phenomenon of environmental refugees is truly global. The dimensions of the contemporary dilemma may be easier to appreciate by taking into account that Third World societies are essentially agrarian. Arid lands alone make up some 35 percent of the Earth's land area, where more than 850 million people, mainly agriculturalists and pastoralists, live (Jacobson 1988). Abandonment of these lands, say from desertification, is a terrifying prospect, not only for the inhabitants but also for the lands and societies that would have to absorb them.

High-tech examples of the nexus are all too common: a single accident at Indian Point Nuclear Plant, near New York City, could require the permanent evacuation of more than 1 million people; a 1 meter rise in sea level (as is now commonly predicted from the "greenhouse" effect) would result in 50 million environmental refugees. By way of comparison, the Chernobyl evacuation only involved 10,000; and the Union Carbide disaster at Bhopal, as sensational as it was, did not directly affect a quarter of a million people (Jacobson 1988). Again, if vast numbers of people are displaced, it is not only their lands and societies that are disrupted, but the territories and peoples that absorb the refugees also will be severely impacted.

Environmental refugees, from whatever disaster, require basic natural resources for fundamental amenities, and they are unlikely to be much concerned about long-term sustainability. There can be no doubt that mankind is poised for ever more massive disasters and ever more multitudinous environmental refugees. The statistics reviewed by Durning (1989) make this frighteningly clear: according to the president of the World Bank, one billion people do not have minimally acceptable standards of living; that is, about one out of four people in developing countries are in this condition—about half of them are in squatter colonies. At least 1.5 billion people lack potable water. Some 27 million babies are born each year, and an estimated 17 million children die annually of easily preventable diseases. About one of four children in Lima, Perú, is physically (and perhaps mentally) stunted from malnutrition. The examples are endless, if not dizzying.

As Wijkman and Timberlake (1984:8) argue, "Disaster prevention and elimination of poverty are closely linked, as are poverty and environmental degradation." Ramphal (*in* Durning 1989:38) is even more forthright: "Poverty is both a cause and an effect of environmental degradation." Yet, disaster relief is often viewed as a series of logistic challenges, exercises in moving men and equipment, much like military campaigns; disaster prevention is virtually ignored by many governments and organizations—even relief organizations—although it would be cheaper and more efficient, to say nothing of being more humane, to plan and invest in preventing the problem in the first place.

"Most disaster problems in the Third World are unsolved development problems" (Wijkman and Timberlake 1984:122), and the conservation formula must obviously take into account socioeconomic development. The linkage here is direct, as can be seen in various case studies (Anonymous 1988, Reid et al. 1988). Durning (1989:32–33) was adamant, stating that "no line can be drawn between economic development and environmental protection" and that "a healthy resource base is a precondition to real social and economic progress."

But "development" in itself is not a cure-all. As mentioned earlier, there is an ever growing stigma surrounding development agencies, for often their projects are not just inefficient or inappropriate, but counterproductive to their stated goals. Worse, the medium and long-term effects of development projects have repeatedly undermined real socioeconomic progress and resulted in drastic environmental degradation. So great is the problem that even senior officers of the World Bank, for example, have published criticisms of their own institution (e.g., Ledec and Goodland 1988).

As Durning (1989:32) explained, "fundamental questions of sustainable development are, ***By whom***? and ***For whom***? Sustainable development imposed from on high is rarely sustainable; it may not even be development." Remarkably, development projects with the best success typically involve small donor agencies that have the flexibility, need and foresight to work directly with the local beneficiaries (Stokes 1978, Reid et al. 1988, Durning 1989).

It is not only the multi- and binational development agencies that are to be faulted, for many national agencies and governments are just as much to blame. It is remarkable how often in the developing world the governments, or power bases which are primarily in the major cities, have little appreciation of what goes on in the rural areas—indeed, they frequently seem to care less (Wijkman and Timberlake 1984). (Again, it is important to emphasize that developing countries as a rule are agrarian-based societies, therefore a significant part of the population—numerically and economically—is rural.) Hence, social and environmental debacles are intimately related to flaws in local governments, helped extravagantly by multi- and binational agencies.

Intimately linked to development is foreign aid, and once again it leads to a Pandora's box. The sums involved are staggering: the total foreign aid for 1986, from rich to poor countries, was $49 billion, and of this the USA budgeted $14 billion. However, what was destined for real development was rather less. First, about 60 percent of the US "foreign assistance" was specifically for military aid and economic support to strategic countries. Second, it is estimated that more than half the money budgeted for foreign aid stays in the donor country (Durning 1989:43).

More significantly, "Much that passes as aid does not foster development, while much development has nothing to do with aid" (Durning 1989:43). As mentioned earlier, even the official multinational agencies have a habit of acting outside the laws of the sovereign countries in which they work, and they are able to elude the usual sorts of accountability. For this reason, it has been concluded that the only way to make foreign aid consistent with real socioeconomic development is by making the aid accountable to its intended beneficiaries. Fundamental to this process is the inclusion of the "underdeveloped" in the processes of planning and decision making. The World Commission on Environment and Development, sponsored by the UN, makes this perfectly clear, recommending: decentralizing the management of resources on which local communities depend, encouraging greater public participation in decisions that affect the environment, providing free access to relevant information, giving local communities effective say over the use of these resources and strengthening local democracies (Durning 1989).

If the sums for foreign aid are staggering, those involved in foreign debt are inconceivable; in round numbers, the external debt of the Third World is $1 trillion, or a million million. According to Durning (1989:44) "In 1988, poor nations gave rich nations $43 billion more in interest and principal payments than they received in new loans." The consequences on countries that bear these monstrous financial burdens have been vast, including economic recessions, declines in demographic indicators and the basic functions of society (e.g., infant nutrition, infant survivorship, life expectancy, health and literacy). The prospects for the debtor nations are terrifying, but it must also be appreciated that large defaults would cause crises in the banking systems of developed countries (Anonymous 1988).

Aside from dangers to economic and social systems, the debt crisis has dire implications on conservation and patterns of resource exploitation. Forestry, fishery and agricultural resources have been mangled by attempts to extract as much as possible as fast as possible to service these debts, crippling prospects of sustained, long-term utilization (Anonymous 1988).

At the beginning of this paper, it was asserted that biological conservation is a human-oriented activity—Soulé and Wilcox (1980:1) call it "mission oriented," and Bell (1987) and Salwasser (1987) give eloquent arguments why people must be included in conservation activities. With this link, the discussion comes full circle; including human needs and human rights clearly ties back to environmental refugees.

Here, also, Durning (1989:54) was adamant on this point: ''Human rights organizations are as important to building a sustainable world as are environmental and hunger groups.''

Gross infringements to human rights that are directly linked to devastation of vast natural areas of unsustainable, fast profit-making projects are becoming more common (Anonymous 1988, Clay 1988, Jacobson 1988, Durning 1989). Principally it is the politically mute, and economically powerless, indigenous peoples and peasants who are supplanted by the wealthy and powerful—the two sides, citizens of the same country (but the conquerors are aided and abetted by multinational corporations and development agencies).

The cause celebré, which reached a climax just over a year ago with his assassination, was Chico Mendes and his work with rubber tappers and Amer-Indians in western Amazonia. Immense areas of tropical rain forest were being worked as ''extractive reserves'' where in 1980 more than half a million people were producing by sustainable, labor-intensive practices, more than $70 million annually in forest products (Clay 1988). Deforestation, for conversion to pasture for cattle ranching, is the primary pressure against these sustainable extractive reserves, and despite the fact that the converted lands soon have very little use—even for their recent owners—rates of forest destruction have grown exponentially (Malingreau and Tucker 1988). The forests of Borneo and the Dayak peoples represent another prominent case of the same phenomenon (Moody 1989), and in fact similar tales are told all over the world.

The result is that indigenous peoples, despite laws that supposedly protect their territories, are driven from their lands by massive changes in land-use practices. If they are able to survive the invasions physically, they are still unlikely to persist culturally. Fully aware of these threats, indigenous peoples try to defend themselves and their lands, but in the end they are no match for the system.

Examples of territorial conflicts in which sovereign governments have acted aggressively against their own citizens, notably indigenous peoples and lower class peasants, have become routine, sometimes clearly involving genocide (Anonymous 1987). Even when the actions are not so aggressive, the end result can be much the same because governments typically undercut local authority but support powerful newcomers who put short-term profits above long-term sustainability (Anonymous 1988, Clay 1988, Durning 1989).

In summary, environmental quality is not a luxury; the majority of the world's people depend on raw materials and basic resources for their immediate needs. When natural resources are not conserved, or are mismanaged in unsustainable ways, these fundamental needs are not met (or occasionally they are actively denied), and simultaneously human rights are violated. This provokes a complicated series of events which typically result in ever greater environmental degradation and ever more human suffering.

Laid out in these terms, it should be obvious that conservation biology involves much more than pure biology, but we as field biologists are often unable to see the forest for the trees. There frequently is a single-minded dedication to strive for more rational use of natural resources, wherever they may be, by working with the tools we know best: taxonomic descriptions, species lists, morphometrics, life tables, vegetation analyses, scat samples and so on. We put tremendous efforts into the creation of parks, reserves and other "protected areas," the enacting of protective legislation and international treaties, and captive breeding programs; more recently, international training programs have become very fashionable.

Yet, despite all this activity and effort—vast sums of money, untold "expert" man-hours—the magnitude of conservation problems seems only to be increasing. Remarkably, the same conclusion has been drawn regarding human disasters: despite vast amounts of money, expert time and other resources, human disasters are simply getting worse year after year. This is not because there are more earthquakes, cyclones, or other dramatic changes in the Earth's climate, but instead "because people are changing their environment to make it more *prone* to some disasters, and are behaving so as to make themselves more *vulnerable* to those hazards" (Wijkman and Timberlake 1984:11).

As long as the relationship between resource bases and power bases remains as it is, massive systems of national parks and reserves, the best wildlife legislation in the world, and wildlife training programs in every college, are not going to turn the tide on natural resource abuse and over-exploitation. The examples of major failures in conservation activities are many and awesome.

For years the national park systems of savanna Africa, supporting unique mammalian megafaunas, were touted as the best in the world, but in recent years it has become clear that the situation is not the Eden which it was once thought to be. Bell (1987) and Matowanyika (1989) give detailed accounts of historical and administrative flaws which have evolved to undermine wildlife conservation in savanna Africa. Peasants and traditional peoples, long subjugated by wildlife protection policies (executed first by expartriates and more recently by powerful urban compatriots), have grown to resent protected areas and wildlife, for they are not only of no benefit, but represent sources of competition for land and other fundamental resources in scarce supply. A vast number of divergent pressures affect wildlife in Africa, and wildlife management is a highly charged political affair—although wildlife managers try (unsuccessfully) to treat it as apolitical.

South and Central America have also been regarded as a naturalist's paradise, notably because of the tremendous diversity of Neotropical life forms. However, despite vast areas gazetted as parks and reserves, extensive conservation legislation and numerous dedicated wildlife people, there is great concern for the future of these natural resources. Mares (1986) and Barborak (1987) discussed several elementary problems: civil strife and militarization, extraordinary financial constraints, and gross deficiencies in trained personnel and also in basic and reliable information; these result in inefficient and inappropriate short-term strategies and a lack of coordinated conservation plans.

In both Africa and Latin America, exaggerations, double standards and an air of panic, generated especially by writers from industrialized countries, hinder the development of long-term conservation strategies. Too often, conservation has been viewed as an activity that excludes people (Mares 1986, Bell 1987, Salwasser 1987).

Where to from Here?

It would be easy to pass off these criticisms as either too liberal or too radical to be taken seriously, depending on one's position on the political bench. However, it is precisely this kind of easy, disengaged dismissal of basic problems that has left us in our present dilemma; clearly, strong criticisms of environmental decline come from *all* parts of the political spectrum, from the USA to the USSR (Durning 1989). A detailed and accurate identification of root problems, and their ramifications, is an indispensable step in resolving dilemmas—only despots and morons would dispute this. What is at stake here is something much more important than political rhetoric—we are dealing with human rights and the availability of resource bases for society in both the short term and in the long term.

Even if one agrees that these convoluted problems are elementary, the obvious question that follows is: so what do we do? The issue of sovereignty and control of the resource base has been focused at two extremes. Units (countries) which are large and heterogeneous often result in internal strife and lack of cooperation. From another point of view, some areas are too small and their utilization patterns and management do not successfully link up with other adjoining and related areas. It may seem paradoxical, but both types of problem can affect the same area or resource simultaneously.

To a certain extent, small is beautiful. Remarkably, a review of successful development projects (Stokes 1978, Reid et al. 1988) showed that in the majority of cases it is the small organizations—not the large multilateral development banks—which have the flexibility and insight to respond to local conditions and have had much greater success. The successes of small grassroots groups (regardless of the political fabric in which they operate) in fighting environmental decline are also consistent with this construct (Durning 1989). Bell (1987) explained why the benefits of conservation activities must be correctly pinpointed, and simply generalizing over large areas is of little use.

An understanding of resource utilization by indigenous peoples (e.g., Nietsmann 1973, Redford and Robinson 1987, Clay 1988) is central to understanding man's relationship with his environment. Also of paramount importance is establishing the rights of indigenous peoples and others who typically, in the modern world, have had an ever diminishing say in their own affairs and especially in the use of their resource base (Bell 1987, Clay 1988, Reid et al. 1988, Matowanyika 1989). Involving these people in decision-making processes on how their environment is to be used and modified seems obvious, but it is rarely done, to the general detriment of countless people and resources (Wijkman and Timberlake 1984). Their participation would ensure not only the democratic process and improved human rights, but also more efficient conservation and sustainable exploitation of natural resources.

Conclusion

It may seem ironic that a discussion of the challenge of international conservation has not mentioned endangered species, nor one critical habitat nor any national park; not a single conservation law has been named, not one conservation program. Indeed, these general concepts have hardly even been alluded to! Frankly, such details would be redundant here—especially for this audience.

Although schoolchildren in the USA may not know where Canada or the Pacific Ocean are (Grosvenor 1989), they almost certainly have heard of the plight of the giant panda bear, or the overexploited blue whale, or even an endangered sea turtle; maybe they have even dispatched a dollar to the World Wildlife Fund to save the panda. Those people who spend half their lives drugged on crack or watching television soap operas may not boast any better knowledge of their world, but they have probably heard some tale of woe about the Brazilian Amazon, droughts in the Sahel or the Valdez oil spill. Perhaps the news even caused them to shake their head in dismay.

We have no deficit of news about species on the brink of extinction, poachers, international wildlife mafias, rates of tropical deforestation, areas undergoing desertification, or polluted air or water. It is not necessary to be an ecologist or wildlife manager to understand that mankind is facing a tremendous challenge in the sustainable use of natural resources.

In 1972, I heard a tourist in Seychelles proclaim, after being given a description of the biology of the islands: "Gee whiz, ecology is everywhere today." So it is with conservation; but replaying the same record, more lamenting about some poor species slipping into extinction or more lurid descriptions of the number of trees per second that are destroyed in tropical forests will not resolve the major issues. Clearly, people must be informed of the details of environmental problems, but that is not the end; we must understand and solve root causes.

The conservation of natural resources—particularly in the international arena—has much less to do with biology than we ecologists and wildlife managers would like; key decisions are in the hands of politicians, economists, developers and that ever-growing tribe of international experts. A week's activities in foreign aid, or international development, or international debt, or political pressures or social conflict, have much more impact on the use of natural resources than do decades of careful ecological studies and wildlife management projects, whether we like it or not. Norris (1978:320) summed up the situation neatly: "In a large part, it seems to me, we talk about managing animals and their environments because it is the easy thing to do. Dealing with our fellow humans and institutions, on the other hand, can stir up immediate responses, often not very peaceful."

On reflection, it is clear that the joke at the beginning of this paper is not a mockery of any one of the people or countries named, but a satire of the sociopolitical system in which "modern Man" finds himself. While ecologists and wildlife managers may not have the political, economic or social clout to redesign our world, we do have the intellectual arms to fight for the changes that are necessary for a sustainable world. It is not just our right to do so—it is our responsibility.

The historic lesson of Auschwitz is not just that despots have maniacal tendencies, but that detached complacency can finally result in a ruined world for everyone. Those of us with comfortable lives in industrialized nations cannot afford to be complacent about either the environmental degradation which is going on ever faster in the developed and undeveloped worlds, or the sociopolitical systems which foster this crisis.

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A Systematic Approach to Regional Cooperation: The Bellerive Initiative in the Alps

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Exactly 100 years ago, a young American arrived in Switzerland to begin his studies in the forests. Gifford Pinchot's studies would take him throughout Europe, but it was Sihlwald, in eastern Switzerland, that he chose as the model for America's National Forests. So it has been in the century since then. Americans have learned conservation from the Alps, romanticized about the Alps, borrowed from the Alps, and longed for the ideal harmony between man and nature that we picture as the Alps.

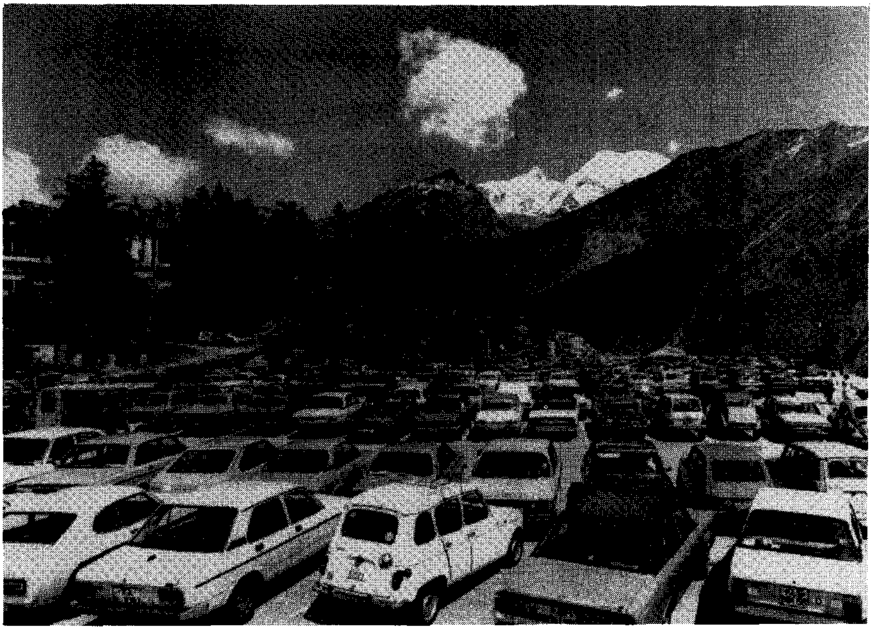
While it is tempting to imagine the Alps towering above—literally and figuratively—the pollution that afflicts other regions of the world, the mountain region is actually in serious trouble. For the third winter in a row, a virtually snowless season has left slopes bare and ski resorts nearly empty. The startling climate has brought to the surface a host of environmental problems, including forest decline, species extirpation, flooding and erosion, air and water pollution, and urban sprawl.

To the visitor, the Alps are still majestic, the farms and communities still charming—but the symptoms are ever more apparent.

- The Alps handle more traffic than any other mountain region of the world.
- Each weekend, at St. Gotthard Pass, automobiles dump an average of 30 tons of nitrogen oxide, 25 tons of hydrocarbons and 75 kilograms of lead into the atmosphere.
- 56 percent of the trees are sick; 15 percent are dead or dying. Forest decline is projected to result in a job loss of 35,000 over the next 30 years with a cost as high as 44 billion Swiss francs.
- As the forests decline, their ability to protect the villages from avalanches and flooding diminishes, the effects of which have already been seen in recent years.
- More than half of all the threatened and endangered species of Europe are in the Alps.
- There are more than 40,000 ski runs, with lifts capable of moving one million people simultaneously—and more on the drawing boards.
- Four of Europe's main river systems (the Rhine, the Rhone, the Po, and the Danube) originate in the Alps. Pollution of the watersheds thus affect the water supply of much of Europe's population.

While the problems facing the Alps—and us—are great, we are at a truly exciting time for the stewardship of our planet. For the first time, conservationists, government, and now consumers and businesses are ready to join forces for the environment. The "greening" of the market place has created the opportunity for *real*, long-term protection—even restoration—of the earth.

Like other regional conservation problems, dozens of organizations, commissions, agencies and research centers have studied the Alps and developed programs to resolve the issues. The Bellerive Foundation, founded by Prince Saddrudin Aga



A cable-car parking lot at Saas-Fee in the Canton of Valais, Switzerland. Although this particular resort is at an altitude of 1,790 meters, new road systems allows traffic to go ever higher-up. The Alps carry more traffic than any mountain system in the world with a combined length of roads and railways just under 500,000 kilometers. The Alp Action programme seeks to promote a more sustainable, long-term approach to development by negotiating financial support for environmentally sound solutions. Photo by W. Roelli, Forch.

Khan, called together the leaders of the conservation community, government and business to assess the situation. The conference developed a ten-point plan for preserving the Alps.

1. An urgent review of current knowledge and future scenarios in key areas: e.g., forests, water, agriculture, tourism, community development, etc.
2. The preparation of an Alpine Conservation Strategy, including a code of ethics.
3. The preparation of a master plan for implementing degrees of protection for ecologically sensitive areas.
4. The support of existing preparations for an Alpine Convention rationalizing existing legislation and exploring new legal instruments.
5. The establishment of a network of scientific monitoring centers with a common data base and connected by on-line computers.
6. The promotion of printed and audio-visual materials for educational and public information purposes.
7. The convening of regular conferences assessing the state of the Alps organized by a focal institution and network.
8. The promotion of more effective local community management including the provision of independent technical advice on the environmental and economic implications of development activities.

Scars left by ski-runs on the flanks of the Piz Corvatsch in the Engadine Mountains of Switzerland. Today, more than 40,000 ski-runs cater for 1.2 million people per hour during the skiing season. The result, overtime, of this annual concentration of skiers is widespread and often unrepairable erosion. Photo by W. Roelli, Forch.

9. The encouragement of the financial community to contribute to conservation.
10. The creation of a fund to support an action group to animate these activities.

A basic conclusion of the conference was that the scientific knowledge, the institutions and organizations, the financial resources—the knowledge, will, and means—already existed to begin the long-term process to conserve the Alps. What was lacking was coordination and communication among the aried interests.

To provide the catalyst, the Bellerive Foundation has launched Alp Action—a cooperative venture to bring all of the players together for practical solutions to the problems. The effort blends government agencies, environmentalists, scientists, businesses and media personalities to focus their combined talents on the regional problems.

Bellerive believes that no single, large-scale project can hope to solve the complex problems of the Alps. Only a myriad of well chosen, practical, small-scale projects can collectively find solutions which are well adapted to the diverse situations.

One of the most innovative elements of the Bellerive approach is the Alp Action Portfolio. The portfolio identifies the key projects being undertaken by diverse groups and individuals to seek support from businesses, other foundations and individuals for the activities. The projects are selected by an international panel of experts. The portfolio serves to publicize the projects and direct funding—from governmental as well as charitable sources—to those projects that are effective. Contributors are able to direct their funds to projects in specific areas of interest to them.

The initial portfolio is modest, consisting of 20 small-scale projects, with a total budget of 1.2 million Swiss francs. But it is a start for a model of cooperation that Bellerive believes will be successful and eventually duplicated in other regions of the world.

The initial projects are distributed in four countries. They involve such simple activities as: Planting trees; controlling torrents; building footpaths and bridges; fencing; environmental education; an award for media coverage; bird surveys; erosion control; and a code of environmental ethics. In return, the businesses can use the Alp Action logo on their products and will receive other promotion in the marketplace.

Appropriate to the new player in the conservation movement—namely, business—Alp Action was unveiled at the World Economic Forum in Davos, Switzerland, February 6. In its first week, nine major businesses, including two American corporations, had announced significant support. Notable among the businesses are several banks.

By this method, gaps or weaknesses in the overall conservation strategies are identified. Initiatives are developed to fill the gaps and strengthen projects. The process spawns innovative projects and builds on strategies from the other parts of the world, including U.S. wildlife management systems.

The unique approach has relevance to American regional conservation strategies being developed for the Chesapeake Bay, Adirondacks, Great Lakes and other areas. The method develops regional cooperation among the various groups and agencies, while allowing each organization to retain its individual identity.

From the Alps, we have learned much that we cherish. One hundred years after Gifford Pinchot chose a Swiss forest as a model for conservation, a new model has been unveiled in Davos, Switzerland—a model of cooperation between business, government and conservationists; a code of ethics for how we all treat the land; sustainable development with a sustainable environment—Alp Action.

The International Workshop on the Management of Wildlife Resources: A Training Tool for Latin America

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Introduction

What Is the Workshop?

The Western Hemisphere Program of the U.S. Fish and Wildlife Service (USFWS), administered by the Office of International Affairs, operates under the mandate created by the 1941 Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere. This Convention, signed by eighteen Western Hemisphere nations including the United States, was created to protect and preserve species of native flora and fauna in their natural habitat and to protect areas of scientific value. Parties to the Convention agreed to take actions to meet these goals, including the adoption of measures to protect migratory birds and species threatened with extinction. In 1983, when Congress provided funds to implement the Convention, it identified several principal tasks: (1) develop personnel resources and programs to facilitate implementation of the Convention; (2) identify species of birds that migrate between the U.S. and other Western Hemisphere nations, identify the habitats of these species, and implement cooperative measures to ensure that these species do not become endangered or threatened; and (3) identify measures for the protection of wild plants.

Developing personnel resources is considered to be the most important component of the USFWS Western Hemisphere Program. Training programs for Latin Americans in wildlife and wildlands management sponsored by the Office of International Affairs include long-term in-country training (e.g., the establishment of graduate programs and protected area management training in Latin America), short-term in-country training (e.g., local workshops and field training), and specific individualized training.

The project discussed in this paper is an example of short-term in-country training, the International Workshop on the Management of Wildlife Resources. Three workshops have been conducted under this title, two in Mexico (1987 and 1988) and one in Costa Rica in 1989.

Brief History

Workshops sponsored by the USFWS Office of International Affairs began in 1980 with an annual series of month-long refuge management workshops; these continued until 1986. Participants in the course visited National Wildlife Refuges throughout the U.S. and learned hands-on management techniques. Between 1983 and 1986, workshops were also conducted on the research, management and conservation of migratory birds. This series of workshops was conducted with assistance provided by the Patuxent Wildlife Research Center in Laurel, Maryland.

The workshops were combined in 1986, made more participatory in nature and were moved from the U.S. to Latin America. This was done to enable the workshops to be more responsive to the participants' needs and to gear the courses toward technologies that were more readily available and usable by them.

Selection of workshop participants was accomplished by soliciting applications through a mass mailing to Latin American conservation organizations and agencies and to universities with conservation or ecology programs. Announcements were also sent to U.S. embassies in Latin America, soliciting their assistance in identifying workshop candidates. Participants were selected by a panel that included representatives from USFWS, World Wildlife Fund—U.S., and the International Council for Bird Preservation-Pan American Section. Other agencies with expertise in Western Hemisphere conservation affairs were consulted regarding the qualifications of potential candidates. These agencies included The Nature Conservancy, the Smithsonian Institution, Manomet Bird Observatory, and organizations located within Latin America.

Objectives

The workshop had both overt and implicit objectives. The overt objectives were to train Latin American biologists by providing a general overview on methods of habitat evaluation and management, endangered species management, environmental education techniques, analysis of environmental impacts, the role of international conservation organizations, and preparation of project proposals to request funds from those organizations.

One of the implicit objectives was to provide a Latin American agency with experience in organizing and running a project of this type. This was accomplished by selecting an agency to act as cosponsor of the workshop. This agency would be responsible for providing a local coordinator to oversee organizational details, select instructors and assist in developing course content. The Costa Rican Wildlife Service was the cosponsor of the 1989 workshop.

The second implicit objective was to bring together a group of biologists and wildlife administrators working at different organizational levels. Over the years, participants' positions have ranged from directors of national wildlife agencies to field biologists and have included representatives from universities, governmental agencies and non-governmental conservation organizations. The purpose was to give those at the upper echelons a better idea of what goes on in the field and to give the biologists working in the field a feel for how agencies are run at the top.

An additional objective of the workshop was to provide a forum for free and informal exchange of ideas and experiences among the participants. Discussions of common problems and frustrations and suggestions for possible solutions to these difficulties were frequent throughout the workshops. This type of informal information exchange had not been generally available to the participants elsewhere.

Workshop Exercises

General Methodology

The 1989 workshop had four major components: wetland management; endangered species management; environmental education techniques; and vertebrate inventory techniques. In each section, the participants were divided into three groups of four, and each group was given a specific problem to solve. The problems were real-life situations occurring in the area. They had three to four days to define the problem further, begin to work towards a solution and prepare a written report on their findings. Afterwards, the entire group met, and each sub-group gave a presentation on its findings. The group as a whole then provided comments, observations and recommendations. When the presentations were given, feedback on team dynamics and report results was provided by local scientists and managers.

Applied Methodology

Many of the 1989 exercises were conducted at the Palo Verde National Wildlife Refuge (officially known as the Dr. Rafael Rodriguez Caballero Wildlife Refuge) located in Guanacaste Province in the northwestern section of Costa Rica. At the refuge, the group lived and worked at a field station maintained by the Organization for Tropical Studies.

The Palo Verde Refuge covers 18,587 acres (7,525 ha) along the Rio Tempisque and has a dry, subtropical climate with distinct wet and dry seasons. Seasonal wetlands have supported thousands of waterfowl, including a number of North American migrants. Surrounding hills within the refuge support a remnant forest community. When the refuge was established 10 years ago, the principal vegetation found in the wetland was the Palo Verde tree (*Parkinsonia* spp.). In recent years, cattails (*Typha* spp.) have invaded the low-lying sections.

Wetland Management

Following the general methodology, the group was divided into three subgroups, and each was given a different problem regarding the management of the Palo Verde wetland. Group 1 was asked to assume that they were the first biologists to work in Palo Verde and that nothing was known of the biology of the area. They were asked to develop a plan to census the vertebrates of Palo Verde for one year, dedicating five person-days/month to field work, and to specify the census techniques they would employ under two scenarios: (1) limited funding; and (2) access to funds from an international conservation organization.

Group 2 was told that large numbers of black-bellied whistling ducks breed in Palo Verde Refuge and that during the latter part of the dry season very little food is available to the birds. Some of the ducks had been observed eating in rice fields of a village located just outside the Refuge. The group was to design a questionnaire and interview villagers to determine their attitudes towards the birds. They were also asked to ascertain what the people knew of the existence and the purpose of Palo Verde Refuge.

Group 3 was told that Palo Verde is a wetland of international importance, particularly to migratory waterfowl. A decade ago, the lagoon was more open whereas now most of the area is covered by emergent vegetation. They were to determine what generated these changes and whether it was probable that this process would continue. Based on the information they collected, they were asked if it would be practical to conserve the wetland as a reserve for waterfowl. They were also requested to determine the effectiveness of prior management at Palo Verde and to offer suggestions for possible future uses of the area.

The conclusions reached by Group 3 are summarized here to illustrate the results of the wetland management exercise. None of the members of this subgroup had any prior experience in managing wetlands and so were unable to compare the management of this wetland to examples of which they had first-hand knowledge. Through published reference materials, interviews with local researchers, conversations with Palo Verde Refuge personnel and visual observations made by the group, they concluded: (1) the present condition of the Palo Verde wetland was primarily the result of factors taking place outside the refuge but within the watershed; specifically that cattle grazing and timber cutting practices had dramatically increased the rate of erosion in the watershed; and (2) this had increased sedimentation in the lower watershed (i.e., within the refuge boundary) and accounted for the drastic increase in cattails.

In order to manage the wetland better, they proposed management alternatives for short-term, mid-term, and long-term implementation. Short-term management included restricting cattle grazing to certain areas of the watershed and constructing a canal to bring water to the area during dry periods. Mid-term goals focused on the development of commercial enterprises within the watershed, e.g., promoting nature tourism in the refuge, developing an arts-and-crafts industry based on cattail flowers, and extracting and selling fertilizer from the wetland. Long-term projects included reforestation of the upper watershed and integrating watershed management considerations into the management of areas surrounding the refuge.

Although Group 3 misidentified the cause of the cattail proliferation within the refuge (it apparently was due to management practices conducted within, not outside, the refuge boundary), the exercise was considered a success because it required them to regard the watershed as a single unit and to consider systematically what effect the management of each part of the unit would have on the watershed as a whole. Given the constraints of time and resources available to the group, the conclusions they reached were within reason.

Endangered Species Management

Participants were divided into three groups and each group was assigned a species to study. Group 1 was given the scarlet macaw (*Ara macao*), Group 2 the snail kite (*Rostrhamus sociabilis*), and Group 3 the jabiru stork (*Jabiru mycteria*). All were asked to evaluate the possible causes of the species' decline and determine the current status of their assigned species within the refuge. They were provided with reference materials and requested to conduct interviews with the local inhabitants. Finally, they were asked to make management recommendations that could be applied effectively in the refuge.

A group comprised of biologists from Argentina, Ecuador, Guatemala and Peru investigated the jabiru at Palo Verde. The jabiru is found in neotropical wetlands, including those at the refuge. After reviewing the available ornithological literature, the group interviewed university and research station staff and made field visits to nest sites to determine the jabiru's local status. Based on this work, the group hypothesized two primary factors which have limited the stork population: (1) loss of wetland habitat in the region due to agricultural drainage; and (2) loss of large nest trees due to frequent dry season fires and strong winds.

The group proposed two measures to augment the jabiru population. First, a number of management activities were recommended, including protection of nest trees, construction of nesting platforms, fire protection and construction of artificial ponds within the wetland area. Second, studies were recommended to determine life history and population trends of the bird within the area.

Environmental Education

The environmental education section of the workshop consisted of two days of classroom lectures and discussion and two days of field exercises. Topics covered in the classroom included fundamental theories and diagnostic methodologies of environmental education, creation of master plans for education programs, environmental education as applied to wild areas management, public use and nature interpretation programs for visitors in wild areas, ecological tourism, and environmental impacts from public use in natural areas.

Following the lectures on the current state of environmental education and public use management and descriptions of specific programs being conducted in Costa Rica, the group visited Braulio Carillo National Park, just outside the capital city of San Jose. The participants were divided into three groups, and each was asked to conduct a survey of public awareness concerning the park. One group was assigned the area just south of the park, one the area north of the park and the last group was assigned inside the park. The questions they asked were directed at determining awareness of the park's existence, the reason for its creation, who was in charge of managing it and what types of management activities occurred inside it.

The group assigned to investigate the area north of the park was surprised to discover a general unawareness in the local inhabitants of the existence of the park. Through conversations with the townspeople, they learned that most of those who did know of a protected area near their village thought it was a reserve for timber cutting. Few of the locals had ever visited the park; those who did usually went to hunt illegally. This exercise illustrated for the participants that even in a country as environmentally conscious as Costa Rica, there still exists a general unawareness of conservation matters, and underlined for them the need for environmental education programs aimed at communities neighboring wild and protected areas.

Vertebrate Inventories

Techniques for conducting bird inventories were included in the program because this topic had always generated interest in past workshops, and it fulfilled the migratory bird directives of the Western Hemisphere Convention.

During the 1988 workshop in Mexico, several days were spent demonstrating avian inventory techniques, including mist netting with and without banding, point census, and line census. In order to illustrate these techniques effectively, the participants were divided into four groups of three. Over a two day period each group spent a half day learning and performing inventories using each of the four techniques.

After each group had an opportunity to try the four methods, the results were collated, and it was determined that both line and point census methods made the most efficient use of time and energy. While mist-netting with banding was the most exciting inventory method, it required a great investment of time and did not yield comprehensive results that could readily be used in a management context.

Although migratory waterfowl were the highlight of the Palo Verde Refuge, the group spent several days studying mammal inventory techniques in upland forests. A mammal expert from the Costa Rican Wildlife Service demonstrated trapping and inventory techniques and emphasized the use of appropriate technology. For example, three groups spent one morning using strip census techniques in different habitat types (dry deciduous forest, evergreen forest, brushland) and recorded visual observations at timed, measured intervals. Comparison of results highlighted the refuge's mammalian diversity, with howler monkeys (*Alouatta palliata*), white-faced monkeys (*Cebus capucinus*), raccoon (*Procyon lotor*), coati (*Nasua narica*) and white-tailed deer (*Odocoileus virginianus*) among the species recorded.

Workshop Products

Formal Presentations

An important component of the workshop is the formal one-hour presentation that participants must give on the state of conservation in their home country and the work they are conducting. Based on written evaluations completed by the participants at the conclusion of each workshop, this has been a useful and productive section and has resulted in a free exchange of ideas among participants working under similar conditions. The discussion period following formal presentations has yielded valuable and practical suggestions for improvements in many participant programs.

El Volante Migratorio

One result of the workshops is *El Volante Migratorio* (The Migratory Flyer). This journal is dedicated to migratory bird research and conservation in Latin America and originated with the 1983 Migratory Bird Workshop. To date, it has published 13 issues. The journal is edited and produced in Peru and receives assistance from the Peruvian General Directorate of Forestry and Fauna, World Wildlife Fund—U.S. and the Wild Wing/Underhill Foundation. It is known widely throughout Latin America as a important Spanish-language forum for publishing new research on migratory birds in the Western Hemisphere.

ALCOVIS

Participants in the 1988 workshop in Mexico City founded the Latin American Association for Wildlife Conservation (known as ALCOVIS by its Spanish acronym), intended to be a professional society for wildlife biologists and managers. Participants found the forum provided by the workshop to be very constructive and beneficial, and they formed ALCOVIS as a way to continue that forum. They felt that the Latin American wildlife arena presents its own unique problems and challenges, different from those in North America and the rest of the world. Sport hunting, for example, is not an important conservation issue in most Latin countries. Integration of wildlands with native peoples, by contrast, is critical to the survival of wildlife habitat. ALCOVIS is presently based in Mexico, and they are now in the process of organizing national chapters.

Conclusions

Numbers Trained

Since 1980, 130 Latin American wildlife biologists and wildlife administrators have taken part in the three U.S. Fish and Wildlife Service-sponsored international wildlife management workshops. Forty-eight participants from 19 countries attended the Refuge Management Workshop between 1980 and 1985 (Table 1); 44 wildlife professionals from 22 countries took part in the Migratory Bird Workshop between 1983 and 1986 (Table 2); and 38 participants from 15 countries attended the International Workshop on the Management of Wildlife Resources between 1987 and 1989 (Table 3).

Evaluation Results

Communication with past participants indicates that the workshop has helped to open a network of contacts among the Western Hemisphere's emerging cadre of wildlife scientists. Most of them have benefitted from the array of management techniques presented during the workshops. Each year, participants' evaluations are reviewed with the intention of improving the workshop experience. For example, following the 1989 workshop the group felt that an additional field site in a different habitat type (such as rain forest or mangrove forest) would have been useful. Also, access to additional reference materials on natural resource management and conservation was a high priority for many who work in areas where such materials are scarce.

Table 1. Nationality of refuge workshop participants from 1980 to 1985.

Country	1980	1981	1982	1983	1984	1985	Total
Argentina				1	1	1	3
Bolivia					1	1	2
Brazil		1	1		1	2	5
Chile			1		1	1	3
Colombia			1				1
Costa Rica	1	1		2	1		5
Dominican Rep		1				1	2
Ecuador		1			1	1	3
El Salvador					1		1
Guatemala		1	1		1	1	4
Honduras			1		1		2
Mexico					2	1	3
Nicaragua	1			1			2
Panama	1	1					2
Paraguay			1				1
Peru		1	1	1	1	1	5
Puerto Rico				1			1
Uruguay				1			1
Venezuela				1		1	2
Total	3	7	7	8	12	11	48

Table 2. Nationality of migratory bird workshop participants from 1983 to 1986.

Country	1983	1984	1985	1986	Total
Argentina		1	1		2
Bermuda				1	1
Bolivia			1		1
Brazil	2	1	3		6
Chile		2			2
Colombia	1	1			2
Costa Rica	1	1	1	1	4
Dominican Rep	1		1		2
Ecuador			1	1	2
El Salvador		1			1
Guatemala	1	1	1		3
Honduras	1				1
Jamaica				1	1
Mexico	1	2		1	4
Nicaragua	1				1
Paraguay		1			1
Peru	2	1	1		4
St. Lucia				1	1
Suriname				1	1
Trinidad				1	1
Uruguay			1		1
Venezuela	1		1		2
Total	12	12	12	8	44

Table 3. Nationality of participants: international workshop on the management of wildlife resources from 1987 to 1989.

Country	1987	1988	1989	Total
Argentina	1	1	2	4
Brazil	1	1	1	3
Chile	1			1
Colombia			1	1
Costa Rica			1	1
Ecuador	1	1	1	3
El Salvador		1		1
Guatemala	1	1	2	4
Honduras		1		1
Mexico	4	3		7
Panama		1	1	2
Paraguay		1		1
Peru	2	3	2	7
Uruguay	1			1
Venezuela			1	1
Total	12	14	12	38

In summary, we believe that the International Workshops on the Management of Wildlife Resources have had a positive impact on Latin American wildlife conservation, and we expect them to continue in a form that serves Latin America's wildlife scientists.

Patterns in Natural Resource Destruction and Conservation in Central America: A Case for Optimism?

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Introduction

The world community is alarmed about the destruction of tropical rainforests because of species extinction, depletion of genetic resources and possible worldwide climatic change (Myers 1986, Prescott-Allen and Prescott-Allen 1983, Wolf 1987). The statistics are not encouraging: about 110 acres (50 hectares) of rainforest are destroyed every minute, totalling 73,000 square miles (190,000 km^2) yearly (Myers 1986). Fifty percent of the remaining rainforests in the world will likely be eliminated by the year 2000 (United States Department of State 1981). Developed countries are pressuring developing countries, which own the rainforests, to protect this world heritage. Unfortunately the factors responsible for rainforest decline are very complex and linked to ecological, social, economic and political problems which vary from country to country. Developed countries share responsibility for the present crisis, making reversal of destructive policies in Third World countries difficult. They have promoted armed conflicts in Third World countries, failed to restrict the accumulation of international debts, and promoted unsound agricultural, development and environmental strategies with financial and technical assistance. In this paper, I will discuss the causes behind the present environmental crisis in Central America, present four successful Central American conservation projects and suggest general solutions to the environmental crisis.

Central America: Its Resources and Problems

The Natural Resource Base is Deteriorating

Central America is made up of seven countries (Guatemala, Belize, El Salvador, Honduras, Nicaragua, Costa Rica and Panama), covers 208,150 square miles (541,190 km^2), or about 75 percent the size of Texas. The region stretches 900 miles (1,440 km) north to south and 300 miles (480 km) at its widest point and contains about 25 million persons. It has extremely diverse natural environments with a unique combination of flora and fauna because of its landbridge position uniting two continents and their migrating biota, its tropical setting between two oceans, and great varieties of climates, slopes, altitudes, and soil formation. Although tropical lowlands make up most of the region, the majority of the human population lives in the temperate volcanic, mountainous areas. The human cultures of Central America are also diverse. All Central American countries include people of European, Indian and African extraction, but the mixture of cultures and races varies from country to country. Although most countries are strongly influenced by Spanish culture and tradition, Belize is predominately of African descent with English colonial tradition. Guatemala and Panama have large indigenous populations and cultures strongly influenced by them.

Despite its cultural, geographical, biological, political and social-economical heterogeneity, Central American countries share a dynamic interrelationship between natural resources, population and economic development. The region has a rich renewable natural resource base that is susceptible to natural disasters and human overexploitation. The economies of all Central American countries still depend heavily on the utilization of renewable natural resources.

Unfortunately, the natural environment is deteriorating rapidly in Central America. Most countries have suffered loss of agricultural productivity due to soil erosion. In El Salvador, more then 50 percent of all arable land is badly eroded. Although development plans in the region and international loans stress agricultural production (Costa Rica received approximately 26 percent of foreign loans in 1989 for agriculture), virtually all optimal agricultural areas are now under cultivation. Emphasis on agricultural development frequently exacerbates ecological problems by subsidizing clearing of steep terrain or high-rainfall areas subject to erosion.

Less then 40 percent of Central America's original forest remains, and over two-thirds of the loss has occurred since 1950 (Figure 1) (Leonard 1986). With deforestation rates increasing every decade since 1950, up to 4 percent of remaining forests are destroyed yearly. Only a small portion of cut trees are utilized commercially. Most are burned or left to rot. Reforestation is usually carried out with exotic species and accounts for less then 10 percent of the deforestation levels. Exported lumber is usually not processed in Central America, so employment potential from forestry is low. At present exploitation rates, no commercial forests will exist in most Central American countries outside of the national parks and equivalent reserves by the year 2000 (Nations and Komer 1983). Wood and wood products are often exploited in these wildland areas and pressure will undoubtedly increase when important areas are stripped. Marine ecosystems are also being stressed by overexploitation, situation due to deforestation, pollution by agricultural chemicals and destruction of mangroves. Lobster and conch harvests have decreased by 41 and 27 percent, respectively, and smaller and second choice species are now dominant species caught by local fishermen (Leonard 1986).

Deforesting watersheds and misuse of agricultural lands on the Pacific slopes of the region has increased costs for dredging sediments in hydroelectric projects, reduced generating capacity and shortened useful life of reservoirs. Finally, coastal ports and important marine life breeding grounds in mangroves and coral reefs are being destroyed and altered by increasing amounts of silting and pollution.

Wildlife species have suffered greatly by habitat loss and overexploitation for meat, skins, eggs and other products. Endangered species lists for some countries now number 100 or more. Vaughan (1983) estimated that in 1983, only 28 percent of original forested habitat remained for 28 endangered species in Costa Rica. Areas available for these species decreased 40 percent between 1940 and 1983. Species most affected at a Central American level include: jaguar (*Panthera onca*), ocelot (*Felis pardalis*), tapir (*Tapirus bairdii*) and the hawk and hawk-eagles (*Accipitridae*). Species with potential for recreation or subsistence exploitation, such as the white-tailed deer (*Odocoileus virginianus*), are frequently rare or absent in suitable agri-

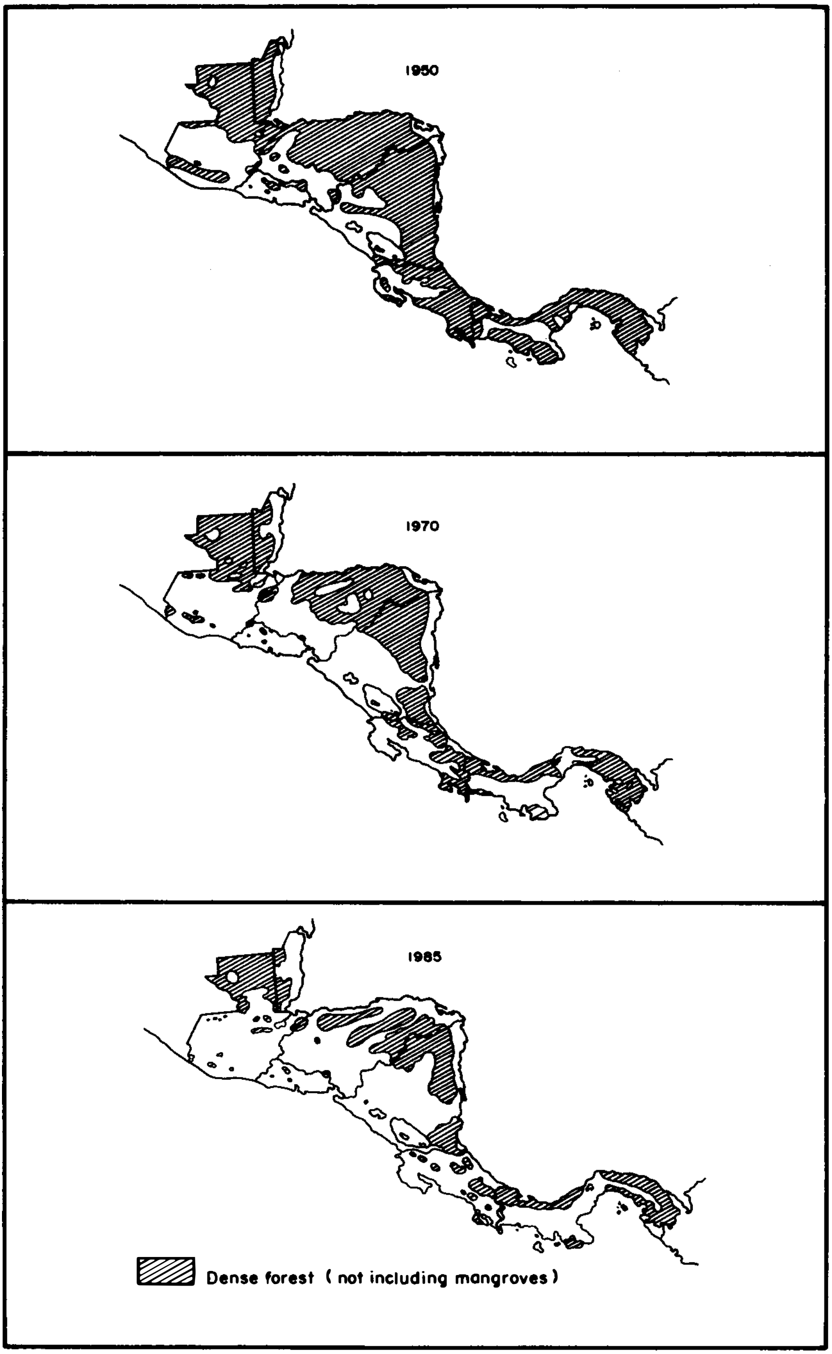

Figure 1. Deforestation in Central America 1950–85.

cultural habitats because of overhunting (Vaughan 1987, Vaughan and Rodriguez in press).

Hidden costs linked to this environmental degradation include lower agricultural yields on eroded soils, increased health problems because of inadequate diets and water contamination, reappearance of malaria and poisoning by pesticides restricted in developed countries. The highly inefficient pillage of natural resources in recent decades for short-term economic gain, has created an ecological crisis. Environmental problems, however, are intimately interrelated with problems within the social-economic-political framework of each country and are oftentimes of international origin, which will be discussed below.

World Champions in Population Growth and Very Rich and Very Poor

The Central American region exhibits wide differences in human population and density distribution, level of economic development and access to resources. Over two-thirds of Central Americans live in the deforested highlands. The slightly populated lowland Caribbean region has 80 percent of the remaining forests and most of the water potential. During the last two decades, human populations in Central America grew more rapidly than in any other region in the world, spurred by Latin cultural values and failure of the Catholic church to recognize the dangers of excessive growth. If it continues growing at the present 2.8 percent average annual rate, it could double its 25 million population in only 25 years (Population Reference Bureau 1986). El Salvador is one of the most densely populated countries in the world. Belize, eastern Honduras and eastern Nicaragua have some of the lowest densitites of humans in the Eastern Hemisphere. Excessive human growth rates have caused migrations to already overpopulated urban areas and the scarcely populated and forested areas in the Atlantic zone. Both migrations negatively affect natural resource management. Urban migration has increased public health problems, crime and drug use, and pollution. Rural migrations, oftentimes with governmental support to reduce pressure on large land holdings and urban migration, have resulted in deforestation and erosion in watershed areas and inadequate soils for agricultural use (Leonard 1986).

Distribution of wealth is very unequal among and within countries. Panama and Costa Rica have three times the per capita income of Honduras or El Salvador. During the 1970s, only 5 percent of the population of Central America received a yearly salary of US$17,600. The average annual salary was about US$200, and half of the Central America population received less then US$74 a year (Torres-Rivas 1983). In some countries, fewer then 2 percent of the population controls nearly all the fertile soil and 60 percent of all the land (LaFeber 1984). The skewed distribution of wealth tends to foment instability in the lower classes. The lower classes are particularly vulnerable to inflationary price increases in essential commodities (electricity, water and food staples) and cutbacks on social services. These are promoted or ''dictated'' by multilateral financing agencies, such as the International Monetary Fund to ''stabilize'' debtor countries (Barry et al. 1982). Instability of outlook often leads to destruction of natural resources, such as deforestation, overhunting or soil erosion, because a long-term view is difficult to maintain under crisis conditions.

External Debt Crisis

Large foreign debts incurred by Third World countries, especially those during the 1970s, sought to keep economies growing and to offset increased oil prices (Barry et al. 1982). The bottom line is that they haven't been succeeding in developing these countries, but instead have played an important role in tropical deforestation and environmental degradation (Gradwohl and Greenberg 1988). The combination of rising interest rates and global recession have made it almost impossible for Central American countries to meet payments. In 1985, the external debt of Central American countries totaled US$16.3 billion; in 1988 it was US$19.5 billion and it is expected to total US$23.8 billion by 1992, or US$900 for each Centroamerican (Varas 1988). Many governments are driven to exploit their natural resources to raise capital. Increased debt leads to increased exploitation of lumber products, seafoods, agricultural products and minerals. Unfortunately, the billions of dollars in multilateral, bilateral and private commercial financing has not been evenly distributed, and instead has gone to the privileged sections, depending not on need, but on creditworthiness (Barry et al. 1982). Food crops for local consumption are lower priority then cash crops for export (Timberlake 1986). Ironically, many of the loans which created debt burden were obtained to promote development projects that accelerated the conversion of the tropical rain forest to agricultural lands, usually pastures for cattle. Even defaulting on loan payments can contribute to natural resource destruction because government economic measures associated with rescheduling payments can result in cutting back on low priority environmental programs in debtor countries (Gradwohl and Greenberg 1988). There are no easy solutions for debtor countries.

Armed Conflict and the Environment

During the Vietnam war, 44 percent of that country's rainforests and mangrove swamps were defoliated with herbicides, and 25 million bomb craters moved an estimated three billion cubic meters of soil. Central America is on the same path of military buildup and environmental destruction as Vietnam in the 1960s. Military expenditures in Latin America rose 75 percent in a decade, from US$8 billion in 1974 to US$14 billion in 1986 (Varas 1988). Men in uniform increased from 47,730 to 207,350 between 1977 and 1985. In 1980 there were 14 tanks, 114 artillary pieces and 223 military planes in Central America, while in 1985 this had risen to 138, 302 and 413 respectively (Gallardo and Lopez 1986). This military buildup took place in a region where in 1980 about 42 percent of the population was in a state of extreme poverty (Torres-Rivas 1983). In addition to transfer of military hardware, military build-up in Central America has been to train police and military and through civic action, intelligence work and coordination with programs (Barry et al. 1982). Part of this military assistance to the region comes in the form of loans, which must be paid back as external debt. Thus, this "assistance" not only destroys human beings and the environment, but must be repaid with interest, creating the problems common to a debtor country (Westling 1986).

Warfare in Central America in the 1970s and 1980s has been restricted to a low intensity strategy by the developed countries (Pearce 1982). Its impact on the environment and human lives is similar to that observed in Vietnam. Agent Orange and Round Up have been reportedly used to defoliate vegetation in Guatemala. Over

3,000 tons of bombs were dropped by the Salvadorean Air Force between 1980–85 on Massachusetts-sized El Salvador (Perez 1987). Up to 10 percent of the coniferous forests in southern Honduras were destroyed as a result of joint manuevers between Honduras and the United States. In Nicaragua, 250,000–350,000 Nicaraguans have fled from their homes and are forced to deforest for firewood, hunt and in other ways exploit the environment (G. Ruiz pers. com.). Other environmental impacts resulting from warfare in Central America include: (a) attacks on or death of researchers, students or governmental employees (guards, administrators) in natural areas; (b) disruption of administration and protection of wildland areas; (c) forest fires, deforestation, erosion, agriculture loss and illegal hunting by soldiers on manuevers; (d) blocking international support for environmental projects; (e) restricting national budgets for conservation work because of defense budgets; and (f) exodus of the best trained professionals in natural resource management from a country because of personal security problems (an estimated 25 percent of Central American university and technical school graduates are living outside the region) (Leonard 1986).

Case Studies of Successful Conservation Projects

Optimism

Given this dreary picture, optimism may seem out of place, but there are enough examples of successful programs in Central America to give some hope for the environmental future of the region. The following case studies were selected to illustrate approaches that have been successful in Central America.

Kuna Yala Biosphere ''Comarca'' (Panama)

Forest conservation goes hand-in-hand with cultural survival of indigenous cultures in tropical areas. Unfortunately, rights of the approximately 3 million Central American Indians distributed in over 55 settlements (Davidson and Counce 1989) have been largely ignored. Although improvements in treatment of some Indians have occurred, others have been dispossessed from their lands, massacred, and denied citizen status, even in the 1980s (Chapin 1989). The relationship between the Kuna Indians and the government of Panama provides an ecologically sound alternative. The Panamanian government under General Omar Torrijos (late 1960s and 1970s) provided indigenous groups with governmental assistance in welfare, education, and public health. As part of this program, the Kunas organized themselves and established a ''comarca,'' or Indian homeland. This homeland was designed as a semiautonomous political organization under the jurisdiction of the federal government. The Panamanian federal and Kuna governments negotiated agreements that allow the Indians to govern themselves. The federal government does not interfere with decisions concerning cultural, economic and political matters which affect the Kunas and their land. The Kuna, in turn, acknowledge allegiance to the state in other matters (Herlihy 1989).

Threats of clearing and burning the 1,230 square miles (3,206 km^2) Kuna ''comarca'' by non-Kunas, were successfully met by the Kuna in the last decade. The internally well-organized Kunas: (a) lobbyied for legal land rights within state ministries and lawmaking bodies; (b) developed a forest reserve and management plan for the reserve, called the Kuna Wildlands Project or PEMASKY, to promote sustainable use of ecotourism, medicinal plants, game, fresh water and construction materials; and (c) focused much of the Kuna community economic activities around the PEMASKY project—for example, all guards, construction workers, technicians, fund raisers, tourist guides, airplane pilots and hotel owners are Kunas (Gradwohl and Greenberg 1988).

Today the Kuna experience with their "comarca" is a successful example for the three other Panamanian Indian groups and other Central American indigenous groups to emulate. For over half a century, the Kuna have maintained this ribbon of rainforested coastlands and islands which extend some 110 miles (175 km) along the Caribbean coast. There are over 40,000 inhabitants today, or about 95 percent of all Kunas in Panama. If the Emberá Chocó, Ngawbere Guaymí and the Teribe are likewise successful in establishing "comarcas," over 3,850 square miles (10,000 km^2) of land, including the largest tracts of rainforests remaining in Panama and among the largest in Central America, would be added to these "comarcas" (Herlihy 1989). The "comarca" legislation, as practised by the Kunas, may be the best hope for integrating centuries-old subsistence economies into the modern world while maintaining ecosystem integrity. Certainly, this successful 50-year project is an outstanding example of Central America conservation.

National Service for Conservation Areas and the National Biodiversity Institute (Costa Rica)

Few countries worldwide can boast of Costa Rica's success in wildland conservation and management. Two decades ago, conservationists were faced with tremendous economic pressures, the world's highest deforestation rate, one of the world's highest population growth rates, land-hungry rich and poor, a legal system which promoted deforestation and high international debt. These visionaries changed public and political opinion, captured large sums of international financial and political support and established a model system of 34 national parks and biological preserves which covered over 2,240 square miles (5,730 km^2) and some 12.5 percent of the national territory. With over 30 other wildland areas (wildlife refuges, forest reserves and indian reserves), by 1985 Costa Rica had 22 percent of its national territory in protected areas (Boza 1988).

Proclamation of 60 protected areas, however did not insure protection of resources. Most wildland areas were "paper parks" and had no boundaries established. Protection was sporadic; personnel were scarce and, in general, not very motivated; no biological inventories had been done in the majority of the areas; funding was almost nonexistent, and coordination of management was lacking between neighboring wildland areas.

Beginning in 1986, the concept of Regional Wildland Units began. Efforts were made to insure protection of representative samples of all ecosystems in Costa Rica. The 144,000-acre (70,000 ha) Guanacaste National Park was created from several adjoining wildland areas and privately owned cattle farms (Janzen 1988). The 60 odd wildland areas were combined into eight regional conservation units, in most cases with one common boundary and an integrated administrative body per unit (Figure 2). Shifting the administrative bodies of these wildlands to the Natural Resources, Energy and Mines Ministry, and strengthening its political position within

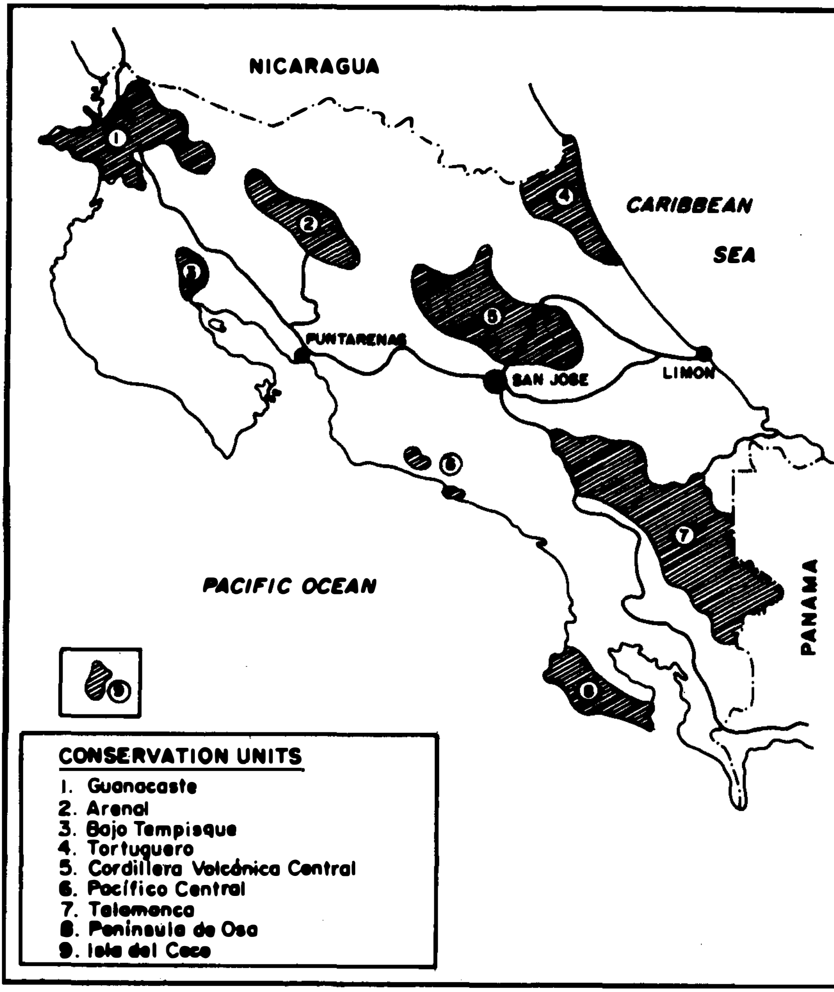

Figure 2. Regional conservation units in Costa Rica.

this Ministry, has been a positive change. Recognizing the magnitude of financial and human resources needed for adequate functioning of this system and setting up private organizations for the administration of human and financial resources destined for management of the wildland units will insure a certain autonomy. In addition, descentralization of the decision-making process in each regional conservation unit by involving local public and private institutions in the directive councils ensures localized participation, as does searching for mechanisms to assure integration of the surrounding human population in each regional conservation unit so they share in the tangible benefits it produces. Finally, utilizing science and research in the establishment and management of these regional conservation units for the benefit of future generations has begun (Costa Rica, Ministerio de Recursos Naturales, Energia y Minas 1989).

The integrated management practiced in individual units will be supported by a newly created Costa Rican National Biodiversity Institute. The National Biodiversity Institute will focus on collecting, cataloging and storing, organizing, identifying, and putting to work for Costa Rica and the international society plant and animal collections from the regional wildland units. This inventory will be the first complete effort for a species-rich tropical country (Lewin 1988) in which the entire biodiversity offerings will be organized. It is envisioned that the Institute will aid social processes such as agricultural and medical manipulation of identified pests, new crops and ornamental species, phytochemical extractions from known plants, gene exploitation from known organisms, management of wildland ecosystems for conservation or material production, intellectural stimulation in education, and research (Janzen 1989). The National Service for Conservation Areas and the National Biodiversity Institute work together in conserving the Costa Rican biota in an intelligent way.

Regional Wildlife Management for Mesoamerica and the Caribbean (Central America)

Many wildlife management problems must be addressed on a regional basis because species and habitats are shared by countries, funding is limited and technical training is most efficiently approached on a regional basis. To increase regional coordination, representatives of governmental wildlife institutions from Panama, Costa Rica, Nicaragua, Honduras, El Salvador, Guatemala and the Dominican Republic unanimously approved the formation of the Regional Wildlife Management Program for Mesoamerica and the Caribbean during a meeting held in Panama in October, 1984. The major objective of this regional program is to provide a body of well-trained professionals in the wildlife-natural resource field who will plan, develop and carry out research, extension and management projects.

Three regional priorities were identified in the Panamanian meeting: (a) training at the graduate and workshop level "in situ"; (b) developing a regional wildlife documentation center; and (c) developing model wildlife management projects in different countries. The Universidad Nacional in Heredia, Costa Rica was chosen to host this program because it was the principal regional institution with a technical and scientific capacity in teaching, research and extension in the wildlife field. Also, university officials at the Universidad Nacional pledged support for the program. Costa Rica was a logical country to host the program because of its peaceful and democratic traditions and history of political stability.

In 1987, the first regional wildlife program in Latin America began the first graduate program in wildlife management in Latin America. Highest priority within the regional program has been establishing the masters degree program in wildlife management. A report on training needs in Latin America estimated that by the year 2000, over 400 professional administrators and 3,400 researchers, teachers and managers would be needed for wildlife and related programs (World Wildlife Fund 1980). Central America currently has only five Latin American professionals trained at the graduate level in a wildlife-related field; 15 Central Americans will graduate in 1990 from our program. To date, 33 Latin American students from 13 countries (Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Ecuador, Bolivia, Paraguay and Argentina) are studying in the graduate program, chosen from more than 140 applicants.

Students and staff feel that training in Latin America has advantages over training in First World countries. Training in Central America prepares the student for the socio-economic-political-ecological context within which wildlife management must be addressed in Latin America. Coursework not only includes the traditional core wildlife courses, but biological conservation, two rural sociology courses, a 42-day field ecology course, a 35-day field integrated management course, a wildlife diseases course, and an environmental education-communications course. The M.Sc. degree is awarded after 27 months of graduate study, which includes three months of preparatory courses, 12 months of graduate course study and 12 months of thesis work. Almost all students have guaranteed jobs upon completion of the program and will return to their countries as trained university professors or governmental or private conservation agency employees. Students average 30 years of age and have an average six years of professional experience before entering the graduate program (Vaughan and Cornelius 1988).

Another priority of the regional program is to distribute technical wildlife information. In Latin America, wildlife study and management has been handicapped because researchers do not have access to scientific literature. Private collections and specialized libraries are uncommon because they are expensive to establish and maintain. Access to "gray" or unpublished literature is also limited. To solve this problem, the regional program inaugurated the first wildlife documentation center in Latin America in 1988. This documentation center maintains over 9,000 reprints in a computerized system, 13 complete journal collections and 400 books, all related to wildlife. It serves as a library for the graduate students, staff and visiting researchers at Universidad Nacional. It will conduct free computer searches for wildlife related work in Central America and is presently involved in compiling "gray" literature from throughout Central America (Vaughan and Cornelius 1988).

Funding for the graduate program and the wildlife documentation center has been provided by the Universidad Nacional, U.S. Fish and Wildlife Service, World Wildlife Fund—US, German Academic Exchange Service, Jessie Smith Noyes Foundation and the Organization of American States.

Model Wildlife Management-Green Iguana Farming (Central America)

The third priority of the Regional Wildlife Management Program is to preserve native habitat and promote research and management projects on exploitable wildlife species found throughout the region. A species where this strategy is working is the green iguana (*Iguana iguana*), which has been used as a source of protein by man for over 7,000 years (Cooke 1981). Meat and eggs from this species is a traditional protein source for many rural poor throughout its range (Mexico to Brazil) (Etheridge 1982, Fitch et al. 1982). However, iguana populations are dwindling due to overexploitation and destruction of their rainforest habitat (Fitch and Henderson 1977). It many countries, it has been declared an endangered species (Fuller and Swift 1985) and, thus, denied to rural people as a legal food source.

The Iguana Management Project, conceived and initiated in 1983 by Dr. Dagmar Werner, staff member of the Regional Wildlife Management Program, is developing the scientific and technical capacity to increase iguana numbers and thus provide both income and protein from eggs and meat for campesinos (Werner 1984). Management of iguanas is compatible with forest conservation and reforestation. Dr. Werner's project combines an economically viable management scheme with appropriate technology transfer, while respecting cultural attitudes.

Iguanas have several biological characteristics which make them a desirable forest species to manage. They are poikliothermic herbivores, with an efficient conversion of plant materials to protein. They consume roughly 10 times less then an equivalent-sized mammal or bird (Gradwohl and Greenberg 1988). They also are highly productive, the females laying an average 35 eggs yearly, or about 300 eggs in an average lifetime. On the negative side, the grow more slowly then chickens, and it would make more economical sense to raise them in forested areas than in cages. Also, in the wild, only an estimated 2.5 percent of a clutch hatch and survive to one year because of high predation. The management program developed by Dr. Werner compensates for high predation by raising young iguanas from eggs and releasing them into forests (Werner in press).

To date, the Iguana Management Project has been very successful. Research has increased hatchability of eggs and hatchling success from 2.5 percent to 95 percent, with young at densities in cages of up to 30 juveniles per square meter. By experimenting with improved nutrition and selecting those animals with rapid growth rates, it has been possible to improve iguana growth rates, and thus egg and meat production. Also successful reintroduction and establishment of iguanas into depleted areas has been carried out with the cooperation of local human communities. Finally, Dr. Werner has determined that iguanas can produce meat at about half the cost of most domestic animals and produce the same amount of protein after a three-year period in a forested area that cattle would produce in a deforested area, without the added benefits of the forest products (Werner 1989).

Epilogue

At present, no region in the world is in greater ecological, political and economic turmoil than Central America. And no region is more vital to United States security, with two-thirds of all U.S. trade and the nation's oil imports and many strategic minerals passing on the Caribbean sea lanes (LaFeber 1984). Washington, D.C. is closer to Nicaragua than to San Francisco. It is a paradox that the vast majority of United States citizens are ignorant about this tropical region, where high diversity of natural and human resources contrasts with stark poverty, inequality in resource distribution and environmental degradation (LaFeber 1984).

With expanding human populations and legitimate expectations for a better lifestyle in Central America, and with mounting armed conflicts and rising external debt crises both nutured by outside sources, current evidence suggests that man's actions in Central America are reducing productivity of natural systems. This trend brings increased risk to the environment and its people. The health of the environment is closely tied to political upheavals, fluctuating worldwide economic forces and endemic poverty in the region (United States Agency for International Development 1989). Natural resource exploitation cannot be sustained at its present level; even with decreases in exploitation pressure as resources become more limited and harder to reach, future opportunities and options for rational natural resource utilization will be lost or reduced (Leonard 1986). Central America is a timebomb whose explosion could have international consequences.

Local governments are limited in confronting deterioration of the natural resource base. Isolated conservation organizations, universities and occasionally government agencies press for sound environmental policies, but they have little political clout. They are not usually unified; they do not have adequate budgets and there are rarely sufficient trained professionals. In the past, most major "resource development" projects with international support have been initiated to bring about short-term increases in agriculture, forestry, fisheries and hydroelectric production by opening new lands, constructing dams and roads, and cutting forests. Very few of these projects have been reviewed for their effects on long-term and sustainable utilization of natural resources. Projects with long-term prospects, such as reforestation, ecotourism, soil conservation, integrated pest control, wildlife management and watershed management, are very rare.

Despite the overwhelming weight of these problems, I believe there is hope. Successful conservation projects are possible and I discussed only four of these. Successful projects generally incorporate local needs, traditions and participation, and international agencies should analyze these aspects of a project before offering funding and technical assistance (Timberlake 1986). Developed countries can assist Central America in lessening environmental impacts by cutting off military aid and reducing external debt by promoting such innovative projects as the "debt swap for nature" (Sevilla and Umaña 1989). Socio-economic-political problems such as high population growth and unequal land distribution must be addressed within national planning agencies. First World countries can assist Central American countries in developing environmentally sound policies. Educating the public and policy makers of developing and developed countries as to the real issues involved in rainforest destruction and environmental degradation in tropical countries is long overdue. Then, with a proper attitude and concrete actions, I believe that Central America, its people and resources will have a chance.

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Effects of the Regulation of the International Ivory Trade on African Elephant Conservation

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Introduction

Significant declines in African elephant (*Loxodonta africana*) populations over the past 40 years resulted from factors associated with the direct competition for resources between humans and elephants, including habitat loss and degradation, and mortality associated with the production of ivory for trade. Much attention was focused on the ivory trade in the late 1970s, and again recently as new regulations were promulgated in the United States and other ivory-consuming nations, and in ivory-producing nations in Africa.

An understanding of the trade is necessary for the implementation of effective regulatory schemes. Large quantities of ivory will continue to be available for trade as ivory currently in trade progresses through the system, and as more ivory is produced as elephant populations continue to decline because of increasing habitat loss, illegal killing, necessary population reduction and natural mortality.

The International Ivory Trade

A comprehensive study of the international ivory trade was conducted by Parker (1979), providing a detailed analysis of the trade that could serve as a basis for regulation. Parker's study, together with declines in African elephant populations, provided a rationale for increased regulation of the trade during the 1980s, although a significant recommendation of Parker's—increased law enforcement efforts in African parks and conservation areas—is only now being implemented.

The ivory trade is an ancient trade that is truly international in scope (Moore 1931, Parker 1979, Ricciuti 1980, Parker and Amin 1983, Conniff 1987). A significant trade in Asian elephant (*Elephas maximus*) ivory existed in India; shortages of this ivory may have brought about the establishment of the current Asian trade routes for African elephant ivory (Martin 1979). Today there is virtually no trade in Asian elephant ivory.

African elephant ivory follows traditional routes to market through Europe and Asia, although shifts in trade occurred during the 1980s as the trade adjusted to changes in market conditions and regulatory pressures. Japan is now the largest consumer of African elephant ivory, while Hong Kong remains the largest marketplace. Several Middle Eastern countries have become significant consumers and transshippers of ivory, primarily as a method to avoid regulatory pressures. The United States is no longer the consumer of raw ivory that it once was (Conniff 1987), although it remains a significant market for worked ivory products.

Ivory serves a variety of purposes in different cultures, including a vehicle of investment (as a "bullion" of sorts), a medium for trinkets of relatively little value and as a medium for art of great value (Parker 1979). The price trends of gold and ivory have closely tracked one another over time (Parker 1979); however, the prices of each have recently diverged, with ivory increasing in price and gold remaining relatively stable. Today, gold trades at approximately $400 per ounce and ivory has sold for as much as $110 per pound (approximately $250/kg). The international trade currently is valued at between $500 million and $1 billion (Gup 1989).

Perhaps more than other commodities, ivory prices rise and fall in anticipation of future supply. For example, in the late 1970s when significant regulation of the trade appeared certain, the price of ivory increased from $20 per pound ($40/kg) to over $35 per pound ($75/kg) in spite of large available supplies. However, during this period the price of gold soared to nearly $900 per ounce so we may never know whether ivory was following gold or reacting to impending regulations. When significant regulations were not implemented, the price fell during the 1980s, only to increase dramatically in 1989 when, once again, regulation appeared inevitable. A paradox of ivory trade regulation seems to be that the prospect of trade regulation drives the price more than supply and demand, and as the price increases, increasing harvest pressure is put on elephant populations, resulting in further supply increases. In many ways, the price of ivory reflects the trade's concern over future supply, assuming a relatively stable demand. However, the relationship between humans and elephants is not simply related to the economics of the ivory trade; humans and elephants appear to be complete ecological competitors (Parker and Graham 1989a, 1989b).

The amount of ivory in international trade remained relatively stable during the past decade at an annual level of 500–800 metric tons; however the trade statistics are inherently suspect because of accounting practices (Parker 1979). Historical levels also seem to be in this range although there are no reliable data (Parker 1979). These amounts do not necessarily correspond to elephant mortality in any given year because ivory is commonly stockpiled for later distribution. Ivory in trade originates from three main sources: elephants killed by poachers, those killed in population management and property protection actions, and "found" ivory from natural elephant mortality. It appears that most ivory in trade today originated from elephants killed by poachers, although this assertion is difficult to verify (UNEP 1989).

The American Ivory Trade

For many years African elephant ivory was an industrial commodity in the United States used for the manufacture of a variety of items including billiard balls, household implements and piano keys (Conniff 1987). Except for high quality piano keys, all of these uses have been replaced by plastics. Different types of ivory, such as African elephant tusks, walrus tusks and sperm whale teeth, have long been viewed as art media in the United States. Walrus tusks provide an excellent carving medium, and several Eskimo artists produced works of great value (Ray 1989). Traditional scrimshaw on sperm whale teeth is also valued highly (Gilkerson 1978). Elephant ivory often is substituted for walrus tusks and sperm whale teeth when these ivories are in short supply or too costly.

Little "raw" African elephant ivory (whole or partial tusks) is imported into the United States; most imported ivory is "worked" (carved or machined as blanks for scrimshaw or other uses). Most current U.S. ivory imports are carvings and jewelry from Asia, primarily Hong Kong and Japan. The market for trinkets such as carved hearts and pendants appears to be declining, but jewelry (bracelets and rings) remains popular although recent efforts to change public attitudes toward ivory appear to be effective (Caldwell and Luxmore 1990, O'Connell and Sutton 1990). Of particular importance in terms of current imports is netsuke from Japan; these small, intricate carvings (several inches high) are traditionally used in Japan as an ornamental cinch for a kimono. The netsuke market in the U.S. is a large proportion of the overall ivory market and consists of many loyal collectors who pay up to several thousand dollars for individual netsukes.

A number of American artists work with elephant ivory to produce carvings and scrimshaw. Scrimshaw is produced in places such as Lahaina, Hawaii and New Bedford and Nantucket, Massachusetts, where whaling once provided tons of sperm whale teeth as raw material (Gilkerson 1978). Elephant ivory is also used for carvings (Zeitner 1979). In recent years, American consumption represented approximately 30 percent of the worked ivory products in trade which were manufactured from approximately 10–12 percent of the total annual exports of ivory from Africa. American imports had an annual value of $18–33 million and approximately 65 percent of American imports originated in Hong Kong; the U.S. received approximately 32 percent of Hong Kong's annual worked ivory exports (54 *Fed. Reg.* 19416, 19417 [5 May 1989]). However, the United States has played a role in African elephant conservation much larger than its presence in the trade.

Regulation of the Ivory Trade

The first significant regulation of the ivory trade in the United States was the listing of the African elephant as a threatened species under the Endangered Species Act of 1973 (87 Stat. 884, 16 U.S.C. §§1531–43 as amended). In 1978, the United States Fish and Wildlife Service (FWS) proposed to list the African elephant as a threatened species under the Act based on reported population declines linked to the killing of elephants for ivory; the Service also proposed four options for limiting the ivory trade in the United States (43 *Fed. Reg.* 2193 [16 January 1978]). Later in 1978, the FWS listed the elephant as threatened and mandated that the U.S. shall trade in ivory only with nations party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); the ivory must originate and be worked only in CITES parties before shipment to the U.S. (43 *Fed. Reg.* 20419 [12 May 1978]). The reasons behind adopting this plan, as opposed to more restrictive options, were to maintain U.S. involvement in the ivory trade, maintain a steady supply of ivory in the U.S. and to encourage the growth of CITES as a regulatory body.

CITES is an international treaty formed under the leadership of the United States (as called for by the Endangered Species Conservation Act of 1969 [Pub. L. 91–135, 83 Stat. 275]), and the International Union for Conservation of Nature and Natural Resources (IUCN). CITES, which came into effect 1 July 1975, provides regulations for trade among its parties based on the effects of trade on the biological status of individual species. Species judged to be most vulnerable to trade pressures are assigned to Appendix I after a vote of the parties. Appendix I includes species "threatened with extinction which are or may be affected by trade." Appendix I classification requires the management authorities of parties to find that trade is not harmful to the species, and to issue import or export permits and certificates of origin. The intent of Appendix I listing is to strictly limit trade. Appendix II includes species which while "not necessarily now threatened with extinction may become so unless trade . . . is subject to strict regulation." Trade in Appendix II species requires only export permits and Appendix II status serves primarily as a monitoring mechanism. Appendices I and II often correspond to the "endangered" and "threatened" classifications under the Endangered Species Act. An important feature of CITES is the reservation provision which permits parties to exempt themselves from the requirements of the treaty for specific species. All of the important participants in the international ivory trade are parties to CITES and several have taken reservations at various times.

The African elephant was listed as an Appendix II species by CITES at the first conference of the parties; the Asian elephant was listed as an Appendix I species (42 *Fed. Reg.* 10462 [22 February 1977]). Concern over the effect of the ivory trade on African elephant populations has been consistently expressed by CITES parties, resulting in increasingly restrictive trade guidelines. In 1985, the CITES Secretariat established the Ivory Control System as instructed by a resolution of the conference. The system encouraged parties to strictly control the import and export of raw and worked ivory, and created procedures through which information on the trade could be more readily exchanged. Most significantly, the system established quotas for the amount of ivory each CITES-party producing nation may export annually. However, the quota did not necessarily correspond to the health or size of a nation's elephant population.

The CITES Ivory Control System was judged a dismal failure by many observers because it operated mostly on an honor system that seemed to encourage cheating (I.S.C. Parker pers. comm.: 1987). Because of the widely perceived negative effects of the trade on elephant conservation, CITES proposed last year to list the African elephant as an Appendix I species. The proposal was adopted during the October 1989 conference of the parties (55 *Fed. Reg.* 5847 [20 February 1990]). However, the parties also established an appeal process by which requests can be made to transfer specific populations from Appendix I to Appendix II. Upon a request for transfer, a panel of experts would be nominated by UNEP, IUCN and TRAFFIC to perform a comprehensive analysis of the status of the population at issue (Resolution of the Conference of the Parties 7.9:1989).

The U.S. Congress enacted the African Elephant Conservation Act as an amendment to the Endangered Species Act to provide U.S. assistance in conservation efforts; the Act was signed into law on 7 October 1988 (Public Law 100–478, 102 Stat. 2306, 16 U.S.C. 4201–4245). The Act was the culmination of over 10 years of effort by several members of Congress. Previous versions of the bill, e.g., H.R. 4685 and H.R. 2826 (96th Congress) and H.R. 4038 (97th Congress), failed shortly after significant media coverage of the crisis in 1978–79 abated, only to be revived during the crisis of 1988–89.

The Act empowered the FWS, through the Secretary of the Interior, to evaluate the elephant conservation programs of producing and intermediary nations, including adherence to the CITES Ivory Control System. If a nation failed the evaluation, the FWS must declare a moratorium on American ivory imports from that nation. The Act also included a new permit requirement and established a conservation fund; funds may be appropriated by the FWS for elephant conservation activities. Congress provided $5 million in 1989 but only $350,000 in 1990. Significantly, Congress recognized that in the future a "limited and carefully controlled amount of trade . . . has the potential to benefit elephant populations by making their conservation of economic value to ivory producing countries" (54 *Fed. Reg.* 14916, 14917 [5 May 1989]).

The first action by FWS to implement the Act was to place a moratorium on the importation of raw and worked ivory from nations not party to CITES (53 *Fed. Reg.* 52242 [27 December 1988]). This action was followed by a call for information which would help FWS to determine whether ivory producing countries meet the criteria for elephant conservation described in the Act. The criteria include:

(A) The country is a party to CITES and adheres to the CITES Ivory Control System;

(B) The country's elephant conservation program is based on the best available information, and the country is making expeditious progress in compiling information on the elephant habitat condition and carrying capacity, total population and population trends, and the annual reproduction and mortality to the elephant populations within the country;

(C) The taking of elephants in the country is effectively controlled and monitored;

(D) The country's ivory quota is determined on the basis of information referred to on subparagraph [B] and reflects the amount of ivory which is confiscated or consumed domestically by the country; and

(E) The country has not authorized or allowed the export of amounts of raw ivory which exceed its ivory quota under the CITES Ivory Control System (54 *Fed. Reg.* 5553, 5554 [3 February 1989]).

If the FWS concludes that a country does not meet the criteria then ivory shall not be imported into the United States from that country.

The FWS requested detailed information covering virtually all areas of elephant conservation and the ivory trade (54 *Fed. Reg.* 5554 [3 February 1989]). Shortly after the call for information the FWS published a proposed revision of the rules governing the American ivory trade; the proposal initiated further implementation of the Act including changes in the requirements for raw and worked ivory imports (54 *Fed. Reg.* 19416, 19417 [5 May 1989]).

On 9 June 1989 the FWS prohibited all ivory imports into the U.S. from producing and intermediary nations under orders from President Bush (54 *Fed. Reg.* 24758 [9 June 1989]). The Service exercised its authority under the Act to declare moratoria on countries that do not meet the established criteria. The Service concluded that,

> (N)o ivory producing nation is able to comply with all of the criteria . . . of the Act. . . . (and) that under current chaotic conditions (in the international ivory trade) no intermediary nation is able to comply with all of the criteria of . . . the Act. Furthermore, the Service has determined that (the) specific criterion (of) avoidance of import of raw or worked ivory taken in violation of the laws of the ivory producer cannot be complied with by *any* intermediary nation [54 *Fed. Reg.* 24758, 24760–61 (9 June 1989)].

The complete moratorium on all ivory imports into the U.S. was based on the innumerable problems associated with the CITES Ivory Control System. As the Service stated: "the volume of ivory trade taking place within the CITES system represents only a small fraction of the total ivory trade and this total now greatly exceeds the annual sustainable harvest of ivory" (54 *Fed. Reg.* 24758, 24759–60 [9 June 1989]). Furthermore, the Service received data indicating that the population of African elephants was declining precipitously on a continent-wide basis and that the African elephant was under consideration for Appendix I status by CITES.

The announcement of the American moratorium was followed by similar announcements in other countries (Coles 1989, Swinbanks 1989) and by the highly publicized destruction of several tons of ivory by the Kenyan government (Henry 1989). These actions were a preface to the CITES meeting later in 1989 during which the African elephant was listed as an Appendix I species. The FWS also announced that it was evaluating a petition to reclassify the African elephant from threatened to endangered under the Endangered Species Act of 1973 (54 *Fed. Reg.* 26812 [26 June 1989]). The FWS recently announced its 12-month finding on the petition and its intent to reclassify the African elephant as endangered, except for populations in South Africa, Botswana and Zimbabwe (55 *Fed. Reg.* 13299 [10 April 1990]).

The Future of African Elephant Conservation and the Ivory Trade

Large quantities of ivory will be available for trade during the next decade as elephant populations continue to decline due to habitat degradation and loss, illegal killing, and population control operations. It is unlikely that ivory will become a valueless commodity, or even significantly reduced in value; the economic forces that ultimately control the value of ivory are too powerful. Therefore, an important issue in African elephant conservation is how to best handle the ivory that exists and that will continue to be produced.

African Elephant Population Trends

Ten years ago, it was estimated that approximately 1.3 million elephants populated the African continent (Parker 1979). In 1989, the population was estimated at 625,000 by the Ivory Trade Review Group of the World Wildlife Fund (Traffic(USA) 1989), a decline of 675,000 in 10 years. Assuming that each elephants bore 1.8 tusks (Parker 1979) and that each tusk weighed 11 pounds (5 kg), 675,000 elephants would yield approximately 552 tons/year (5522 metric tons) between 1979–89. This annual figure is consistent with estimates of the total annual amount in trade before stockpiled ivory is counted. The 11-pound (5 kg) estimated mean weight was selected to represent a significant reduction over earlier estimated tusk weights (e.g., approximately 20 pounds (8–10 kg) from Parker 1979) based on the many reports that young elephants are now commonly killed; Parker's estimated yield of 1.8 tusks per elephant also may no longer apply for the same reason. In 1979, Parker estimated an annual overall harvest rate of 2.6–3.3 percent for Africa; current population estimates seem to represent an acceleration.

Estimating African elephant populations has long been an inexact science (Wing and Buss 1970, Laws et al. 1975, Burrill and Douglas-Hamilton 1987, Cherfas 1989a). Burrill and Doublas-Hamilton (1987) describe an effort to use computer modeling to estimate elephant populations on a regional basis, and their data indicate a total continent-wide population of 1,021,000 elephants—an estimate that the authors suggest may be inflated because of overestimates for Central Africa. Extrapolating elephant numbers retrospectively from ivory trade statistics is possible, although the trade statistics themselves are suspect. Clearly, the overall population trend is downward. This conclusion is well-documented by Parker and Graham (1989a, 1989b), who found that elephant population declines are best understood in terms of competition between human and elephants for limited resources.

The Economic Value of Elephants

The economic value of African elephants has long been recognized as has the prospect of using this value for conservation purposes. Laws et al. (1975) described an elephant conservation program for implementation in Uganda financed by ivory and other elephant products. Unfortunately, as in so much of Africa, political instability prevented the realization of the program.

Arguments in favor of establishing elephant conservation programs financed by the sale of elephant ivory and other products are popular (Simmons and Kreuter 1989). To paraphrase the argument of proponents of such plans, we should "sell elephants to save them." Proponents of these plans cite the rapidly expanding human populations of Africa and the deteriorating economies of many African nations; money is not available from national budgets and therefore elephants must "pay their own way." "Elephant-financed" conservation can work but only in the presence of political and economic stability.

Elephant Conservation in Zimbabwe and East Africa

Zimbabwe won independence in 1980 and since then has become a leader in African wildlife conservation. Zimbabwe's success has been due to a solid conservation infrastructure that remained relatively intact after independence, thereby maintaining established elephant conservation programs. Furthermore, during the long civil war preceding independence, the bush was too dangerous for poachers and Zimbabwe's elephant population thrived (Hallagan 1981). Elephants in Zimbabwe are found primarily in the national parks and safari areas; hunting is permitted only in the safari areas but population control is conducted in both types of conservation areas. Management of elephants and other large mammals is subject to well-defined methods and objectives (Cumming 1981, 1983). Zimbabwe also instituted several innovative land-use plans attempting to integrate wildlife conservation into local economies (Martin and Taylor 1983). Tourism is an important contributor to the national and local economies in Zimbabwe but has yet to reach the magnitude of tourism in Kenya.

Simmons and Kreuter (1989) base their arguments for maintaining and expanding the commercialization of African elephant ivory largely on the successes of Zimbabwe, South Africa, Malawi and Botswana, each of which has had relative political stability. The success of Zimbabwe should be admired and serve as a goal, but it cannot serve as a rationale for establishing similar programs elsewhere, especially in East Africa. Economic conditions in East Africa are much worse than in Zimbabwe; unlike Kenya, Tanzania and Uganda, Zimbabwe is a net food exporter and has a well-educated population (Henry 1990). Zimbabwe can serve as a model for the future, but outside of southern Africa the priority must be to gain control of wildlife conservation areas.

Increased law enforcement has long been advocated for East Africa but not implemented because of political instability and a lack of financial resources. Furthermore, many previous efforts failed to account for the needs of the local people and were rendered ineffective (Parker 1983a). The national parks of East Africa are where current efforts should be concentrated. The park systems provide a rallying point for national pride and already have the legal and operational infrastructure necessary to provide a framework for action; in other words, nothing new needs to be created, existing procedures need only to be implemented effectively. Only after law enforcement efforts succeed can implementation of Zimbabwe-style management practices begin. Intensive efforts should begin now because it seems inevitable that elephants will be limited to areas such as national parks in which they can be adequately protected; the days of free roaming elephant populations are nearly over. If managed properly, even relatively small parks can sustain healthy elephant populations (Hall-Martin 1979).

Financing elephant conservation efforts in the national parks is a primary concern. In Zimbabwe, conservation projects are financed through the sale of elephant products, including ivory, from revenues obtained from tourism and trophy hunting and from the general treasury. Financial resources are scarce in East Africa. Kenya derives significant income from tourism but other East African countries do not (Eltringham 1984). Significantly, the countries that need the most financial assistance for conservation seem the least likely to have profitable tourism industries because they are often politically unstable.

Because financial resources are scarce in many parts of Africa, they must be used wisely. A direct relationship exists between the viability of African elephant populations and conservation spending (Leader-Williams and Albon 1988). In instances when financial resources are scarce, the existence of many large conservation areas may be a disadvantage because they cannot be adequately managed. By concentrating on national parks a choice is made to give other areas a lower priority; choices may have to be made to concentrate on particular priority areas within an individual park.

A longer-term view of the economic aspects of elephant conservation should also be advocated. The slaughter of elephants today represents the obvious conclusion that the resource is worth more today than at some point in the future. This conclusion is not uncommon in natural resource management even when sustainable yield management programs are employed (Clark 1989). One way to combat this is to include the local people in the conservation effort by providing employment opportunities and education on the longer-term view that wildlife will be worth something in the future. Such a program, called Project Campfire, is used in Zimbabwe. As Parker (1983b) emphasized, wildlife conservation programs must take into account the needs of indigenous populations and include a certain degree of flexibility.

Ultimately, the issue of financing elephant conservation programs must be addressed by the developed world. Several African countries that have suffered severe elephant population declines, including Kenya, recently renewed their commitment to conservation efforts. These countries are looking to the developed world for help. Developed countries have a variety of means through which to provide financial assistance, including grants, loans and innovative debt-for-conservation swaps. Increased and immediate assistance is needed for African countries to regain control of their conservation areas. Congress provided only $350,000 in 1990 for the fund established by the Elephant Protection Act. Several European countries and Japan have indicated that they will fund some elephant conservation activities. However, adequate funding requires a significant commitment from developed countries. It is estimated that $200–400 per square kilometer is required annually to finance conservation activities in Arican parks and reserves; this estimate results in a total annual requirement of $100–200 million (I.S.C. Parker pers. comm.: 1990).

The Future of the Ivory Trade

The objectives of a trade ban have not been clearly articulated but can be expressed as follows: (a) the ban should help to bring the trade under control by limiting the supply of ivory, (b) the ban should help to change public attitudes toward the consumption of ivory, thereby reducing demand, and (c) by reducing supply and demand, pressure on elephant populations may be reduced providing time for the implementation of sound conservation programs. However, as Parker and Graham (1989b) noted, the relationship between the economics of the ivory trade and elephant populations appears to be exaggerated. A ban clearly is not necessary for the preservation of the species because a number of African elephant populations are secure. Furthermore, the African elephant is remarkably resilient; greatly reduced populations have recovered if given adequate habitat and protection (Hall-Martin 1979).

The stringent controls on the ivory trade instituted by CITES in 1989 and the trade bans announced recently by a number of ivory producing and consuming countries are likely to have several effects. First, the price of ivory is likely to remain high, although in the near future it may decline below its current historic high of $110 per pound (approximately $250/kg) because of existing trade bans. The high price of ivory may have several effects, including the increased incentive to kill more elephants to produce more ivory, although there are few objective data to support this perception (Parker and Graham 1989b). Also, higher prices may mean that ivory will be used almost exclusively for value-added art objects such as netsuke, carvings and scrimshaw, and as an investment vehicle. Second, recent restraints are likely to cause further contraction of the trade as fewer people are likely to enter a trade with a questionable future, and as people in the trade look elsewhere for opportunities. Third, ivory consumption patterns are likely to change as public attitudes become more negative toward ivory, resulting in less demand for ivory products. The ivory trade may exist in the future only as a much smaller version of its current state. Preliminary information on the effects of the trade bans suggests that they are effective in reducing demand for worked ivory, particularly in the U.S. (Caldwell and Luxmore 1990, O'Connell and Sutton 1990).

Zimbabwe, South Africa, Zambia, Botswana, Malawi and Hong Kong (through the United Kingdom) are CITES parties critical to the successful regulation of the ivory trade that entered reservations to the Appendix I status of the African elephant, and continue to trade in ivory (C. W. Dane, pers. comm.: 1990). Zimbabwe proposed the formation of the Southern African Center for Ivory Marketing, which would coordinate ivory sales for Zimbabwe, Botswana, Malawi and Zambia (Cherfas 1989a). Because several producing and consuming nations may continue to trade in ivory, problems similar to the alleged abuses of the CITES quota system may continue. This is a particularly difficult issue because countries such as Zimbabwe, with sound conservation programs, are penalized by the recent CITES listing of the African elephant as Appendix I despite their successful conservation programs.

The reservations raise an issue that continually has plagued the CITES Ivory Control System, the accurate identification of the country of origin of ivory. Currently the countries of origin are monitored through CITES permits which allegedly have been widely falsified. However, the fact that four out of the five producing countries that filed reservations (Zimbabwe, South Africa, Botswana and Malawi) have sound elephant conservation programs, including good management of their ivory, may help the current system to function properly, provided that ivory-consuming nations follow the new constraints on trade. New techniques are under development that may permit the accurate identification of the area of origin of ivory. These techniques, which involve DNA typing and carbon isotope ratio analysis, are several years away from implementation (Cherfas 1989b, Lewin 1989).

Summary and Conclusions

The recent trade restrictions can be positive for elephant conservation if properly implemented. However, implementation has historically been a serious problem in African elephant conservation. Problems often result from the lack of an appropriate regulatory infrastructure and inadequate funding. The fastest growing human populations in the world are in elephant territory in countries in which the majority of people live in poverty. The most effective means for positive change will be to use the sparse financial resources to achieve limited and specific objectives such as enhanced law enforcement in the national parks and to provide economic opportunities to people living with elephants.

The international ivory trade is an ancient trade. The overall value of ivory held around the world probably runs into the billions of dollars, and it is unlikely that this value will be greatly reduced by anti-ivory attitudes and restrictions on trade. However, changes in attitudes and trade restrictions may help to bring the ivory trade and the killing of elephants under control, within the constraints imposed by the nature of human/elephant competitive interaction. The developed countries of the world, including the major consumers of ivory, must step forward to provide financial assistance. If adequate financial resources are provided, it may be possible to implement sound elephant conservation programs to ensure the survival of healthy populations in African parks and conservation areas.

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International Conservation: A Challenge to All

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Those who espouse complete protection of populations of some species of wildlife that have been utilized to fund conservation efforts and without regard to human needs defeat the purpose for which they work. Four examples or case studies are presented to make this point: the elephant in Africa, the jaguar in Latin America, the tiger in India, and the Serengeti ecosystem in Tanzania.

The African Elephant

Biopolitical considerations for elephant conservation in Africa have resulted in a "Catch 22" dilemma, made so by recent events at the meeting of the parties of the Convention on International Trade in Endangered Species (CITES) in Switzerland in October 1989. All elephant populations were placed on Appendix I (endangered status) by parties to the convention. Although it does not prevent sport hunting and exceptions can be filed by countries, this action and legislation prohibiting import of elephant products by North American and European countries will have an important effect on elephant harvests.

The ban on imports of ivory from African elephants by the United States is well-intentioned, but too pervasive for all of Africa. Complete protection of elephants may be appropriate in one area but inappropriate in others. In several southern African nations, elephant populations support offtakes from which sales provide funds for already meager conservation budgets. Properly managed, elephants can make a great contribution to the economy and esthetics of a country. Poorly managed, they are a detriment. Regulating elephant numbers and distribution is the key to proper management.

In elephant management, whether we in the conservation community like it or not, we must accept that man's welfare comes first. A major activity of wildlife departments in Africa for years has been the protection of man from the depredations of elephants (Kinlock 1972), and that is not going to change. To do so would be as unrealistic as restoring unfettered herds of bison to the grasslands of North America.

Elephants have the ability to drastically alter their habitat (Buechner and Dawkins 1961, Buss 1961, Petrides and Swank 1965), and loss of habitat from overuse has probably contributed as much as overshooting to elephant declines in Africa in the past three decades. Where elephants have been crowded into diminishing habitats through pressures of man's development of the natural world, elephant numbers have increasingly been at risk (Buss 1961, Laws and Parker 1968, Buechner and Dawkins 1961, Field 1971). Probably the best documented decline of elephants as a result of overpopulation was in Tsavo National Park in Kenya from the mid-1960s through the early 1970s (Laws, 1969, 1970, and 1971). There, some 6,000 animals died from starvation after their habitat had been destroyed by their own activities and by drought (Corfield 1973).

Ivory has been a source of income to the people of Africa from the beginning of history (Baker 1866). Properly managed, elephants can continue to supply revenue to countries sorely in need of it. However, the recent action by CITES will lead to serious losses of revenue for several African countries that have large, viable populations of elephants. Offtakes in those countries provide a significant source of funds for already paltry conservation budgets.

Between 1967 and 1989, 12,771 elephants were culled from herds in Kruger National Park in the Republic of South Africa. Elephants numbered between 5,590 and 7,486 animals during these years (Files of Kruger National Park, personal communication I. J. Whyte). Many of these were pushed into the park from neighboring Mozambique where populations were already at peak numbers and poaching was high. Culling was done to protect elephant habitat and for other species whose habitats were impacted by overuse of the vegetation.

Zimbabwe has a population of elephants that has increased on the order of 5 percent per annum since the early 1900s when the population was around 5,000 head (Cumming 1981). Elephant management in Zimbabwe is a case in point where wise use of a wildlife species has served to protect it. Zimbabwe, Botswana and Malawi are similarly affected.

More than 52,000 now occur in Zimbabwe, which is some 19,000 more than the habitat can support in the long term. A total of 44,506 or an average of 1,536 (range 332 in 1963 to 5,339 in 1983) have been harvested each year from 1960 through 1988 in Zimbabwe through culling and sport hunting (Martin et al. 1989). The sale of 244,297 pounds (111,044 kg) or ivory from 30,859 tusks between 1981 and 1988 brought in US$ 7,613,982. The sale of hides, feet, tails, dried meat, and calves produced another US$ 5,628,053 for a grand total of US$ 13,242,005. A quota of 139 trophy bulls was set for sport hunting in 1989. These were offered on 15-day safaris at an average cost of US$ 11,250. Thus elephant hunting had a potential earning capacity for Zimbabwe of US$ 1,563,750. In summary, the annual revenue from elephants in Zimbabwe has amounted to about US$ 4,700,000.

Elephants also provide a strong incentive for safari hunting in Zambia. Safari hunting there yielded gross foreign currency equivalent to US$ 4.5 million in 1985 (Cumming 1989). Trophy and lease fees earned $0.62/ha in safari concession areas and $0.25 per hectare in communal land in 1985. Fees from such activities go to the authorities who control the land—parks and wildlife department, farmers, forest department, etc. Thus on communal lands, fees are important to local peoples. Income is a strong incentive to protection and conservation efforts at all levels. The elephant is a sort of "leader" in marketing other wildlife in safari hunting.

Uncontrolled and illegal killing is now an alarming factor in elephant management, and indeed elephants are endangered in a great part of Africa because of the economic value of their ivory. The price of ivory jumped from US$ 2.85 per kg in 1950 to $74.42 in 1978, and annual imports to developed markets jumped from 28,725 kg to 73,912,920 kg over the same period (IUCN 1980). The price per kilogram now is much greater.

A review of history, however, shows that populations at various times and places have been at risk since the middle of the last century. Prior to the great ivory trade in the last half of the nineteenth century, elephant numbers were said to approach several million animals. They were exceedingly scarce in southern Africa by 1880 (Selous 1881, MacKenzie 1987), were on the decline in Kenya by 1896 (Neumann 1987), but were still abundant in certain portions of East Africa until 1906 (Bell 1987). At the turn of the century less than 5,000 occurred in Zimbabwe and perhaps 10,000 in the Republic of South Africa.

The last of the great commercial elephant hunters (Selous, Bell Neumann) ceased their activities with the institution and enforcement of game laws by the colonial administrations in eastern and southern Africa in 1906. Afterwards, elephants began their slow upward climb from the verge of extinction to overpopulation, habitat degradation, and population crashes in East Africa (Laws and Parker 1968). No verifiable estimates could be found, but there probably were at least ten million elephants in Africa in 1960. Estimates placed African elephant numbers continent wide at one to three million (Jackson 1983). A more recent estimate placed elephant numbers at 750,000 (African Elephant and Rhino Specialist Group 1987). Losses apparently have been most severe in east and west central Africa. Now, most elephants occur in central and southern Africa, which is a complete turnaround in distribution of numbers on the continent since the turn of the century.

Will the recent action by CITES accomplish the desired goals of restoring elephant populations in east and central Africa? The CITES Secretariat stated at the meeting of the parties in Switzerland in October 1989 that transfer of elephants from Appendix II, threatened, to Appendix I would be counterproductive to the species' conservation. The Secretariat's position was that some populations should have the status of endangered; others, threatened. It cautioned that placing all populations of elephants on Appendix I would result in an imminent increase in the price of ivory and provide an even greater incentive for poaching and illegal trade. However, the program recommended by the Secretariat did not carry the day.

Giving the local people who have day-to-day contact with the animals a vested interest (income) in elephants, and providing better organized and more efficient anti-poaching measures, seems a better solution than placing the elephant on Appendix I. No one can deny that the loss of funds for conservation from any source, and the maintenance of overpopulation of elephants in a setting where man himself is imperiled, is a serious risk to the whole wildlife conservation movement.

India's Project Tiger

In examining the context of conservation in India and elsewhere in Third World and developing nations, one must conclude that failure of conservation efforts is a foregone conclusion if conservation plans are not made and implemented in social, economic and cultural contexts. This translates to meeting human needs.

If human needs are not met, wise use is not an option. The result will be poaching and other exploitative measures by local peoples. Preservation is the only strategy available where resources have been squandered—i.e., where habitats are lost and populations of especially herbivores are depleted or even completely extirpated. Only small relict natural areas and examples of life can be preserved in the long term under such conditions. Preservation by setting aside parks and reserves as a strategy too is flawed when wildlife numbers outstrip their habitats and leave protected areas to depredate villagers' crops and kill or compete for forage with their livestock.

We have no intention to demean Indian conservation plans. India is somewhat special among developing nations in that its cultural and heritage values are now preservationist in character. This has not always been so, for the rajas and colonials were inveterate hunters. Among the common man, philosophically, all life is revered. Sometimes their conservation strategies lead to ecological denigration of the very things they desire to protect. Of course, these are value judgements of a western culture. In any case, India is making valiant efforts to preserve her wildlife wealth while at the same time meeting basic needs of a burdensome population. Unhappily, her efforts are laudable but are seriously at risk. Human numbers and their needs are at the root of the problem.

Project Tiger is hailed as one of the great success stories of restoration of a threatened species in a developing nation in recent history. But its success exemplifies conflicts between needs of wildlife and people throughout the developing world.

At the turn of the century, tiger numbers were estimated at near 40,000 in forested habitats throughout India. They were reduced to near 1,800 through loss of habitat and sport hunting by 1973 when Project Tiger was inaugurated by Indira Ghandi, then the most influential champion of conservation in India (Panwar 1987). Complete protection was given the tiger. Sixteen sanctuaries and national parks in India have since been set aside as special tiger reserves. Special management for tigers was initiated on the sanctuaries. The area in the tiger reserves comprises 3.2 percent of the forest area and 0.77 percent of the total area of the country. Traditional uses of the designated tiger reserves by villagers were stopped. In some cases entire villages were moved outside parks. Tiger numbers increased to 3,015 by 1979, and to more than 4,000 by 1987 (Panwar 1987). The latter figure is questioned because of the census technique used (pug marks); however, it is certain that tigers are much more numerous than when Project Tiger was begun and probably approach the number estimated.

The tiger is recognized as a symbol of the wealth of the jungle, and many companion species have been protected by its management. It is the vehicle for protection of an enormous gene bank in a faunal and floral diversity almost unmatched and certainly unique in the world. It has the goal of protecting basic resources of soil, water and vegetation from man's intemperate uses.

But what has been the cost of Project Tiger to people, and what has this success story meant to conservation in India and to other Third World nations?

India's human population growth is among the highest in the world. It grew from 238 million to 361 million between 1901 and 1951, and made the enormous increase in 685 million by 1981, an increase of over 900 percent in 30 years. Its population of 618.7 million in 1975 was judged by FAO experts to contain 119 million more people than its agriculture could support (FAO 1982). Presently, over 800 million people inhabit India, whose land mass is roughly one-third that of the United States. Depending on whose figures you accept, from 13 to 20 million souls are inexorably added to India's population every year.

The Green Revolution has forestalled collapse of India's food base, but agricultural production is perilously close to failure to keep pace with its burgeoning mass of humanity. The average supply of calories per capita, most of which is produced in-country from wheat, paddy rice, millet and sorghum, totals 2,056 units (FAO 1984).

About 50 grams of protein and 32 grams of fat are included in the caloric values. Caloric intake for Indians is about two-thirds that of European peoples. European supplies of protein per capita are twice that of India's and fats about five times. Very little cereal grains are fed to livestock; rather, it is consumed almost entirely by humans. To feed each year's population increase, India must produce an additional 2.34 million tons of grain to sustain the daily ration of 500 grams per adult (Daniel 1986).

Firewood provides about 50 percent of cooking energy; cattle and buffalo dung are almost equally important, especially for rural peoples. With just a fortieth of the total land area of the world, India supports more than half of the world's buffaloes, 15 percent of its cattle, 15 percent of its goats and 4 percent of its sheep.

With such pressure, the natural environments are going downhill with each new generation. The protected reserves are being pressured by people who must find ways to live (Rathore 1986). Peasant farmers and graziers have an insatiable need for land and for fodder for their animals. Sources of firewood recede farther and farther from villages. Forest reserves are often devastated by people who do not confine their activities to gathering fuel from downed and dead trees but tear limbs from live trees for fuel and fodder. As one Indian official put it, "even if we somehow grow enough food for people in the year 2000, when our population is to be over one billion souls, how in the world will they cook it?" (Eckholm 1975). About half the total land area is grazed by livestock and lands not in cultivation are virtually impoverished.

Opposition to parks and reserves has escalated to violence. Six people were killed at a confrontation between villagers and parks authorities at the Keoladeo Bird Sanctuary at Bharatpur in November 1982 after park authorities announced that grazing in the park was banned (Center for Science and Environment 1985). Over a thousand villagers marched on Rathambhore National Park, a designated tiger reserve, in a confrontation over resources in 1987. These are not isolated incidents; most sanctuaries and parks are pressured by people who attempt to satisfy their needs by incursions onto protected lands.

Man-eating tigers are part of the lore of British India. Although records are poor, attacks by tigers have increased as tigers increased. From 1975 to 1982, an average of 45 people, largely fishermen, were killed annually by tigers in the mangrove habitats of the delta of the Ganges/Bramhaputra rivers, a part of which comprises the Sundarbans Tiger Reserves. Twenty people were taken by tigers in 1983 and 1984 near Corbett National Park, and 125 were taken between 1983 and 1985 around Dudwa National Park (Center for Science and Environment 1985). Although measures are being taken to prevent attacks on humans (Ward 1987, 1988), attacks continue near tiger reserves. Losses were reduced to less than 25 per year in the Sunderbans when models of men were used as aversive agents to tiger maulings (Sanyal 1987).

India's political and conservation leaders understand their dilemma. Nonetheless, they press on to expand their efforts. The Wildlife Action Plan places parks and sanctuaries as the keystone of conservation efforts for the country. Fifty-four parks and 372 sanctuaries totaling 109,652 square kilometers or 3.3 percent of the country's land base were in place in 1987 (Rodgers and Panwar 1988). While recommendations from their study have not been officially adopted by the Government of India, their report contains a proposal to expand protected areas to 651 areas totaling 151,342 square kilometers, or 4.6 percent of the country's land base (Rodgers and Panwar 1988).

An article in *Sanctuary Asia* magazine (Anonymous 1988) which was devoted to Project Tiger put the problem squarely on record with an introduction to descriptions of each of the 16 tiger reserves:

> Given all the constraints, it would be difficult enough for us, as a united people, to execute a vital national priority such as the saving of our forests; but our forest officers were, and still are, being asked to do this job in an environment of hostility, with little or no public or political backing. As of today, almost every area is ringed by a hostile, hard-pressed people whose simple needs have not been catered to by our government. As a result they look towards the forest for their sustenance and come into conflict with forest guards and officials whose instructions are to protect the few jungles that we have, at all costs.
>
> It would be quite accurate to say that one of the main problems in implementing conservation action plans in India has been the lack of widespread public support for nature conservation. For years, in fact, it was only a tiny segment of the educated elite who concerned themselves with conservation. And their objectives were really not understood. Most people thought conservationists were involved in an esoteric exercise in saving obscure animal or plant species, and that such attempts were a waste of time in a country where the priority should be saving people, not wildlife.

Admittedly, India may be a worst-case example, but it is prophetic for many less developed nations. To have protected areas in the very midst of poverty and from which the people receive little or no benefits is a paradox which promotes active antipathy to conservation efforts. How long can conservation efforts be sustained in the face of such numbers and needs of people?

The Jaguar—A Symbol of Conservation Efforts in Latin America

As the tiger in Asia, the rhino and elephant in Africa, and the whooping crane in North America have become symbols of nature conservation in those continents, the jaguar has become a symbol of conservation efforts in the Neotropics. An apex animal formerly of very wide distribution and an animal of mystery occurring in relatively rare numbers even in pristine settings, the jaguar now occupies only 33 percent of its original range in Mexico and Central America and about 62 percent of its original range in South America (Swank and Teer 1988). Formerly occupying habitats in every nation from Mexico to Argentina, it has now been completely extirpated from several countries and is on the verge of extirpation in several others.

Commercial hunting has played a part in the reduction; however, loss of habitat was and remains the chief cause of its decline. Commercial hunting is not now a factor in the species' future. The CITES has been effective in removing the market. Losses of jaguar continue, however, through continued losses of habitat and by opportunistic killing by campesinos and by ranchers who kill them to protect their livestock.

Jaguar populations are presently secure in undeveloped areas ''protected by nature''; i.e., protected by inaccessibility, distance, and in areas inhospitable to man for one reason or another. Setting aside lands to protect the species is not a viable alternative because most reserves are too small to contain the species' needs and, more importantly, reserves in Latin America are not often managed and protected by personnel on the areas. The long-term future of the species is at risk and will remain so until local people begin to get some economic and social returns and have an incentive to protect it (Swank and Teer 1988).

Dr. J. Ojasti (1984) summed up conservation efforts in Latin America as follows:

> . . . Appropriate game laws and official agencies in charge of wildlife now exist in most Latin American countries and some efficient management programs are in progress. . . . The number and area of national parks are increasing. International treaties such as CITES and other agreements contribute to reducing the skin and primate trade. On the other hand, the game laws and closed seasons are generally ignored and even the national parks are not safe for wildlife. Most hunting practiced in Latin America would be termed poaching by European or North American standards. The law enforcement is lax or operative only in the checking points along main roads for urban sport hunters. Factors like long distances, lack of roads, price of fuel, guns and shells, scarcity of game, and landowners who prohibit hunting on their lands may afford more protection than the official game police. . . . The top administrators of developing countries face urgent problems of economic development, politics, education, health, etc., and pay attention to the natural resources only when their productivity and monetary returns are large. When the resource becomes scarce, it is not politically important. This is the case of wildlife in many Latin American countries, due to excess exploitation and habitat damage for generations.

M. A. Mares (1986) was somewhat more sanguine in his appraisal of the future of wildlife and the natural world in South America when he wrote:

> South America's problems regarding the use of natural resources are the result of historical, sociological, economic, and scientific factors. Most countries in South America have done a great deal to encourage conservation efforts, but the magnitude of the problem is well beyond their limited economic means to solve. The problems of species disappearance in South America are of global importance. A successful solution will involve a coordinated and massive effort of governments and specialists in all aspects of conservation biology from throughout the world.

Protected Areas and Parks: The Greater Serengeti Ecosystem

Of the more than 3,500 parks and reserves in the world, those which are between 1,000 and 100,000 ha in size (IUCN 1985), at least half are little more than paper reserves. They have been gazetted and mapped but are not protected or managed for the resources for which they were established. Very few field staff and only miserly budgets are available for them, indeed for all conservation efforts, in Third-World Countries.

The Serengeti/Mara ecosystem with its assemblage of plains game is without question one of the great wildlife spectacles of the world. This enormous protected area is the focus of the tourist industry in East Africa. It is an extremely important source of foreign exchange for Kenya and Tanzania. However, there is little evidence to show that benefits of the industry filter down to local people. Further, governments of the developing nations net very little of the total tourist dollar. Much of the profits remain in the countries from which the tourists depart. Airlines, travel agencies, and tour operators are the primary beneficiaries. Few are in-country businesses. One estimate places the portion of the tourist dollar accruing to the developing nations at not more than 20 percent of gross sales.

Pressures of grazers, subsistence farmers, and poachers have increased to put at risk this great ecosystem (Kurji 1979). In Kenya, where 80 percent of the population is rural and only one fifth of the country arable, the overburdened land has a population growing at a rate of 3.6 percent annually. Pressures of people on parks and conflicts between wildlife and people outside parks are major conservation issues (Lusigi 1981). Tourism is an extremely important source of foreign exchange which may be lost. Lusigi recommends wildlife conservation reserves patterned somewhat after Biosphere Reserves where people may share in resources with wildlife, a strategy becoming popular in many developing nations.

Threats to the Serengeti/Mara may not be typical of all parks of the world but are, however, a pattern becoming all too common for many parks and sanctuaries. Threats are particularly dire in countries where human numbers and poverty are constants in life support systems.

Without consideration for the human condition, parks and sanctuaries, indeed conservation efforts in general, have little chance of success in the long term. The same may be said ultimately for even the affluent nations in the western world. We can presently afford whooping cranes and an expenditure of more than $41.4 billion in 1985 for hunting and fishing recreation (U.S. Fish and Wildlife Service 1988), a sum that exceeds the total national budgets of a dozen African nations.

The Priorities of Developing Nations and Conservation Strategy

In our lifetimes, we have seen rather dramatic changes in conservation strategies. Through lessons learned in the past, the likes of which we described above and others which failed altogether, international conservation organizations have begun to change from protectionist to management strategies that satisfy human needs and consideration of the human condition. Further, we are linked geographically, ecologically and economically. Parochial interests are no longer possible; ours is indeed a global world in practically every aspect of human life.

Aside from elemental human needs of food, homes, health care, education and jobs, priorities of developing countries—indeed, for all nations and peoples—are social justice (human rights), national sovereignty (political identity and partnership), and economic stability (enough for most). Conservation of wildlife and wildlands is inextricably linked to these needs.

The World Commission on Environment and Development in the so-called Brundtland Report (Brundtland et al. 1987, IUCN 1984) offers hope for reversing the slow but steady attrition of the natural world. Simply stated, it makes the case that conservation is linked to all facets of human life and proposes that conservationists consider the human condition at local levels. We cannot dismiss the strategy it proposes as rhetoric, as some have done, even though applications of sustainable development are often extremely difficult at local levels.

Without these considerations, efforts to save many of the world's great ecosystems and the diversity of life in them will fail. Those of us in the affluent and developed nations are parts of the problem and the solution. All of us are challenged.

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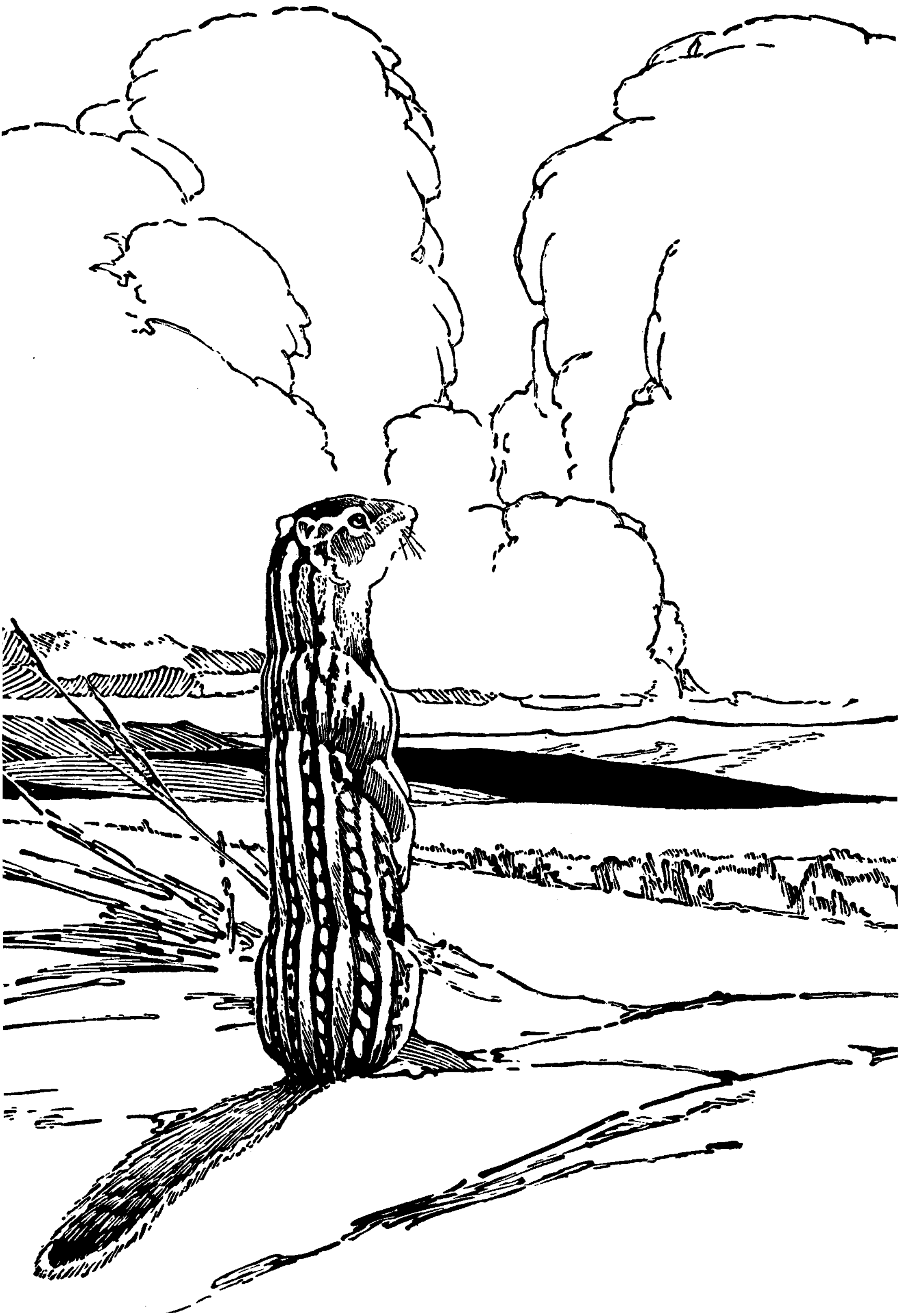

Special Session 9. *Rangeland Management Needs*

Chair
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Public Lands Foundation
McLean, Virginia

Cochair
J. S. TIXIER
USDA Forest Service
Ogden, Utah

Introductory Remarks

George Lea
Public Lands Foundation
McLean, Virginia

I want to welcome you all and thank you for choosing our session. The other concurrent session has made your decision difficult, but I am certain that our topic and papers will be rewarding for you. This is the first time, to my knowledge, that a session on rangeland has been included in the North American. We believe the discussion this afternoon will show the need to continue this subject at future conferences.

Let me begin by introducing myself. I am George Lea, President of the Public Lands Foundation—a newly formed private, nonprofit, organization of retired BLM employees who are dedicated to professional management of the public lands and natural resources under Bureau of Land Management (BLM) administration. I founded the Foundation following 31 years with BLM.

Stan Tixier, our co-chairman is currently regional forester at Ogden and president-elect of the Society for Range Management (SRM). Stan has a broad background, which includes line and range and wildlife staff positions in the southwest and eastern regions and the Washington office of the Forest Service. Stan will participate and summarize our session.

Implied in the title of this session, ''Rangeland Management Needs,'' is the question: What are the needs? I have spent a good share of my career thinking and dealing with this kind of land. I see several needs some of which will be touched upon by our papers this afternoon.

Definition

To start with, it is significant and may not have been noticed that the title of our session is rangeland needs, not grazing land needs or range management needs. Our subject is about a kind of land, rangeland.

And so the first need I see is to recognize that we are dealing with a kind of land and not a use. The term describes a landscape, not the products of the land. Along with a better understanding of the term rangelands, there is a need for a broader and increased public awareness of the value of rangeland. As a land form, many consider it unglamorous, uninviting and low in values, the least productive, when in reality it is a very exciting place to work, to study and to play in. The inclusion of our session in the conference will help meet this need.

Perhaps the Society for Range Management's definition is a good beginning. SRM defines rangeland as a broad category of land comprising more than 40 percent of the earth's land area, and characterized by native plant communities, which are often associated with grazing and are managed by ecological, rather than by agronomic methods. Rangeland resources are not limited to grazeable forage, but may include wildlife, water, recreation, scenic, scientific and other benefits and values. With such a large area of such geographic scope, we can only barely touch on it in the time we have today. I am sure you will agree that the papers we have time for do no more than fool around on the margins of the subject.

Agreement on Terms

In addition to a clear definition, rangelands suffer from a lack of agreement on terms used to describe and to measure the health and condition of the land. Arguments prevail between interest groups as to the status of rangeland conditions. Some say they are in good condition, better than they have been for 50 years. Others can look at the same land, the same statistics and say no, not so: that their condition is poor and failing. This lack of agreement is not a helpful argument and lawsuits and poor communications results.

Application of Research

Another need is understanding the role of research. The U.S. has been a leader in research efforts to understand the ecology of rangeland, and we have more than 50 years of study behind us to guide management and use. While there will always be a need for more research, especially related to wildlife and recreation, we do have a good knowledge base for management. The need here is to understand that improved management need not wait for more research. If we could apply one half of what we know we could make great progress in needed improvement.

Livestock as a Tool of Management

And finally, we are coming to realize more and more the importance of livestock grazing, when performed properly, as a major source of changing vegetative conditions to produce desired multiple benefits. In fact, proper grazing of livestock is more often compatible with other uses of the land. The need here is for more demonstrations of this management tool and public acceptance of the results. Two of our papers should bring this point to the fore.

Direction: A Range Management Need

R. H. Barrett, Jr.
U.S. Soil Conservation Service
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Introduction

My purpose here today is to offer you a view that might be incorporated with your definition of rangelands in the hope that it will influence your perception and management of that resource. I will propose a direction that might unify those of us who live and work with these lands.

Like many range conservationists, I have an educational background in plant ecology, physiology and taxonomy; in soil morphology, development and classification and I have passed the full complement of animal husbandry and range improvement courses. As a student, I saw rangeland as a distinct kind of land that differed from all other lands in its processes, behavior and treatment. Perhaps subconsciously the neat separation of the resource departments on campus supported this belief.

I accepted with little question many of the traditions and myths of what is lovingly referred to by range professionals as "the art and science of range management." I was able to recite, almost without thinking, the lessons of the "catechism of range management." The definitions and use of terms like *range readiness, proper use factors, carrying capacity* and *animal unit months* were at the ready for any test, conversation or argument. In a way, these definitions stood as proof that we range professionals operated from a definitive and scientific platform.

And I recognized the view that some creeks, creekbanks and springs were "sacrifice areas" that had to suffer for a greater good, just as I accepted that to make an omelet, you had to break a few eggs.

Code of the West

But I spent my youth on our family ranch in the hills flanking Higgins Canyon, a small tributary watershed of Pilarcitos Creek which flowed through the town of Half Moon Bay on its short run to the Pacific. In those years I saw the grass dry and the soil crack during our long dry summers, and watched runoff meet a swollen Higgins Creek during winter downpours.

I came to know plants, not so much by name, but by growing season, color, smell, taste and allergic reaction.

I knew the amazing variety of a horse's diet, what cattle avoided, where deer spent a warm afternoon and the many ways of starting a grass fire.

I knew where the trout lay and where their favorite grubs could be found, and I could track the poachers that rushed the opening of fishing season.

I knew by the mare's tails in the western sky and by the smell of the wind that rain for the newly seeded oats was on its way.

And I knew that runoff, diverted from small gullies and spread over the hillside, left a fresh layer of soil before sinking into the ground.

But then I went to college and learned plant names and how to identify them by their flowering parts.

I learned of animal preferences and of quantum mechanics and exothermic reactions.

I learned of the components of fish and wildlife habitats, of their nutritional requirements and diets.

I learned about climate and weather, and soil development and infiltration rates.

I read the classical works of Odum, Clements and Daubenmire and I put away the things of a child.

Among those things I put away was a simple idea which, in later years, has resurfaced to strongly direct my approach to resource treatment. It has been a great help to me in recognizing resource values and appreciating the scope of resource deterioration. It has helped in identifying cause and effect of current rangeland conditions, in determining appropriate treatment and, over time, that treatment's degree of success. I will offer you that direction in the right context a little later.

Degree in hand, I went to work with the Soil Conservation Service (SCS) in northern Nevada, confident that range management, with its attendant concepts, was the modern day "code of the West." I saw, instead, the deep arroyos north of the Winecup Ranch in the northeastern Elko County, and the deep, broad entrenchment called Long Creek that runs north from Peavine Mountain, near Reno, to Honey Lake, east of Susanville. I saw pinyon pine and Utah Juniper filling most niches in the Pine Nut Range east of Carson City and believed it natural that streams top their banks in late winter and spring and go dry in summer.

Later in Washington and Oregon, and in spite of different climates, geology and latitude, I saw more similarities than differences in range condition, stream entrenchment, and in the wide amplitude of high-flow, no-flow water regimes.

Evolution of Thought; Explosion of Controversy

Now, with that as prologue, I would like to offer my view of the field called range management and to point out one possible direction for the future management of the rangeland resource. I have walked this path and am quite sure you will enjoy not only the journey but the destination.

My generation of range professionals began its formal training when we cracked open our new copies of Stoddart and Smith's *Range Management* where, on the first page, range management was defined as ". . . the science and art of obtaining maximum livestock production from range land consistent with conservation of land resources." During our first reading assignment it could be deduced that this "science and art" germinated in the newly established national forests and lands administered under the Taylor Grazing Act in the first half of the 20th century.

Since these beginnings, the sciences and arts of range management have expanded to offer an enlarged view of this great resource—of its functions and processes, its products and its economic and environmental importance. With this expanded understanding have come new disciplines with growing ranks of specialized disciples. Rangeland hydrology, rangeland recreation, rangeland wildlife, landscape ecology, rangeland economics, and bio-engineering can be traced in some degree to the concepts of range ecology and the dynamics and multiple values of the rangeland ecosystem.

I have come to learn that today's definition of range management is linked directly to our individual experiences and the work that fills our own horizons. In my exposure to rangelands and to those working with its resources, I have built my personal view of range management and I appreciate that there are other opinions that in no way resemble mine. Therein lies the fuel for the evolution of thought and the powder for the explosion of controversy.

Often these differing views are the source of confusion and conflict among range managers, range users, legislators and the public. To a great degree, the source of these differences is that we have confused the uses of these lands with their inherent nature and value. We have emphasized products at the expense of function; become engooed by its romance and ignored some of the realities; gotten mired in the manual and lost some of our practicality. But we all have our myopias, don't we? Each of us seeing the resource through our own personal squint.

Definitions

I suggest that if our preferred use or component of the range dominates our definitions of rangeland and its management, we should not be surprised by controversy, conflict and litigation. If rangeland is defined as sage grouse, as dirt bikes, as cows, as sagebrush, juniper or knapweed control, or as antelope, we put the resource and our plans in harm's way. If, on the other hand, we can recognize the importance of each of these elements and employ them within a definition that encompasses a greater view, these myriad interests will fit the landscape, promote resource health and productivity, and meet the social demand.

I once assumed that everyone had a vision of the land at its potential—I know that real estate developers do, and drainage engineers do. But when I speak of potential I imply the native, or natural potential of an ecosystem in which soils, plants, water, climate, insects and animals interact freely to express the combined voice of the environment. It has been my experience, unfortunately, to find that visions of native potential are not commonly held, or if held, are not openly discussed. I do, however, see uses and treatment applied quite liberally. But in what direction, what context and to what end? Do all uses fit all landscapes? Do some treatments apply to every situation?

Direction: To Capture, Store and Safely Release

Range management involves a working knowledge of plant community dynamics, wildlife habitat and food requirements, livestock breeds and marketing, grazing system and fence design, and the techniques of brush control and seeding. But, in condensing the years and experiences of my career and those years as a kid knocking around the Coast Range, I submit that a deeper, fundamental knowledge must be employed in the treatment of rangelands. We must recognize that all the values and uses of these lands flow from the healthy functioning of the water cycle. Our common approach should address rangelands, regardless of use, as watersheds. So in speaking for that young boy and the lessons he learned from cool summer creeks and grassy hillsides during winter storms, I suggest that our work should be aimed at improving the soil's ability *to capture, to store* and *to safely release moisture*. It is this direction that SCS in Oregon has taken in its approach to rangeland resource treatment and is the stated aim of our Range Resources Treatment Plan.

To explain:

—To capture moisture through the management of plants and soil that encourages the infiltration and deep percolation of water for plant use, for sub-surface and groundwater recharge, and to reduce overland flow and sediment yield.

—To store moisture by encouraging plants and plant communities that protect the soil surface from the drying effects of sun and wind; and to wisely treat plant community imbalances that cause transpiration of excessive amounts of soil moisture.

—To safely release moisture through seeps, springs and streams as they quietly drain watersheds of their surplus moisture rather than act as conduits that dry them out.

An Ancient Irish Curse

I know that when uses are made of these lands with this concept in the forefront, a little science and a little art can make a great difference. After working with SCS and ranchers in eastern Oregon and other parts of the Intermountain West, I am forced, perhaps by some ancient Irish curse, to see things not as they are but as they could be.

I see the entrenched stream channels and drained meadows of desiccated watersheds returned to wet and diverse, bird-loud glades. I see returned the sod-covered lakes of former riparian plains once again storing the moisture that supports stream flow through July, August and September. I see willows and cottonwoods counter the calving creekbanks of previous conditions and I watch creeping wildrye, Nebraska sedge and silver cinquefoil trap the rich sediment shed by slowly weathering uplands.

In my mind's eye, I allow lightning its rightful place and function in the landscape, relieving sagebrush and juniper of the awesome responsibility of dominance. And I see returned the original soil surface to today's exposed clay subsoil—a surface containing enough organic matter to trap the rain from the garden variety summer-thundershower; a soil surface that supports a variety of plants that steal the shock from raindrop impact and insulate the soil from all but the deepest freezes, hottest sun and driest wind.

In closing I will say that this direction—to capture, to store and to safely release moisture, has helped give perspective to our view of the land, its treatment needs, if any, and the success or failure of our management. The long-term effect of the application of this and other concepts aiming at native resource potentials is the healthy functioning of the rangeland ecosystem supporting the variety of uses on which we and our economy depend.

Conservation of Biological Diversity on Western Rangelands

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Introduction

Loss of biological diversity is an emerging national and international concern. The Earth's biological diversity is being rapidly reduced at a rate without precedent (Wilson 1988). Although this issue is often associated with tropical ecosystems, other regions are equally threatened. Rangelands comprise about 70 percent of the world's land area (Holechek et al. 1989). Thus, even though these regions may not have as much species diversity, loss of biological diversity from rangelands will also have significant global implications. In the 11 states west of the 100th Meridian, rangelands also comprise about 70 percent of the land. The post-settlement history of the West has had a common theme of exploitation and often destruction of biological resources, beginning with the beaver trapping and followed a few decades later by widespread extirpation of bison. So far, the decay of biotic diversity in the West has involved primarily the loss of distinct populations and parts of ecosystems, rather than the extinction of entire species or ecosystems. But the accumulated losses of populations and ecosystem fragments could soon add up to a permanent disappearance of many species and communities (Ehrlich 1987). Conservation of biological diversity on these rangelands is desirable for ethical or aesthetic reasons. More compellingly, biological diversity provides the basis for a sustainable ecosystem, economy and society. Thus, it is essential to the welfare of the people of the West.

In this paper, I (1) review current concepts of biological diversity and their evolution, (2) review current interest in biological diversity, (3) describe current threats to biological diversity on western rangelands, (4) review current programs related to conservation of biological diversity on western rangelands, (5) discuss new approaches that will be necessary to conserve biological diversity on western rangelands and (6) discuss the need for awareness and action based on understanding the relationship of biological diversity to sustainable ecosystems and sustainable economies.

Current Concepts of Biological Diversity

Biological diversity has many connotations. The Office of Technology Assessment (OTA) has developed the following definition:

> Biological Diversity refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different items and their relative frequency. Thus, the term encompasses different ecosystems, species, genes and their relative abundance. (U.S. Congress, Office of Technology Assessment 1987).

Numerous other definitions are available; however, most current definitions are characterized by (1) explicit recognition of three levels of diversity (ecosystem, species, genes) and (2) a broader description than the "species diversity" indices in vogue in the 1960s and 1970s, which typically involved a quantitative diversity index.

The OTA definition has been criticized for not explicitly considering both form and function. Therefore, a U.S. Bureau of Land Management (BLM) advisory group developed the following definition of "biodiversity:"

> Biodiversity is the aggregate of species assemblages (communities), individual species, and genetic variation within species and the processes by which these components interact within and among themselves; for purposes of classification, biodiversity can be divided into three levels: (1) community diversity (habitat, ecosystem), (2) species diversity, and (3) genetic diversity within species; all three levels change through time.

This definition more explicitly recognizes both form (structure and composition of ecological communities) as well as function (ecological processes such as succession; evolutionary processes such as speciation). Thus, conserving biological diversity includes more than just recovery of endangered species or creation of preserves. It also encompasses maintaining ecological processes and preserving the capability of genes, organisms and communities to evolve over time.

Current Interest in Biological Diversity

Current concern over loss of biological diversity in this country has led to a major study by the OTA (U.S. Congress, Office of Technology Assessment 1987), numerous conferences and symposia resulting in books (Soule and Wilcox 1980, Soule 1986, Wilson and Peter 1988) and an emerging discipline termed "conservation biology." A Society for Conservation Biology was founded in 1986 and publication of its journal, *Conservation Biology*, commenced in 1987 (Soule 1987). More recently, legislation to mandate conservation of biological diversity has been introduced in Congress (Blockstein 1988).

This rapid emergence of a new discipline has caused much unrest in some of the older conservation disciplines, particularly wildlife management (Capen 1989). Some have suggested that conservation biology is merely an old profession (wildlife ecology and management) under a new name (Teer 1989), whereas others have embraced the new discipline (Thomas and Salwasser 1989).

Biological diversity is neither a new buzzword for an old concern nor an environmental fad; rather concern over loss of biological diversity is a logical extension and evolution of a conservation movement that dates back to at least the 18th century in this country (Cooperrider 1989). From this perspective, legislation such as the currently proposed "National Biological Diversity Conservation and Environmental Research Act" (HR 1268) represents a broadening of our concern for organisms from a concern for certain species groups to a concern for all species (Figure 1). The act also represents a similar expansion from a concern over particular ecosystems to a concern for all ecosystems (Figure 2). Finally, a concern for gene conservation is a logical result of our modern understanding of evolution and of population genetics.

Conservation mandates as articulated in legislation have generally resulted from increased awareness of threats to the particular element(s) of biodiversity. The original game conservation laws in this country were a reaction to declining numbers of game species. Similarly, the original forest reserve legislation was a reaction to rapid

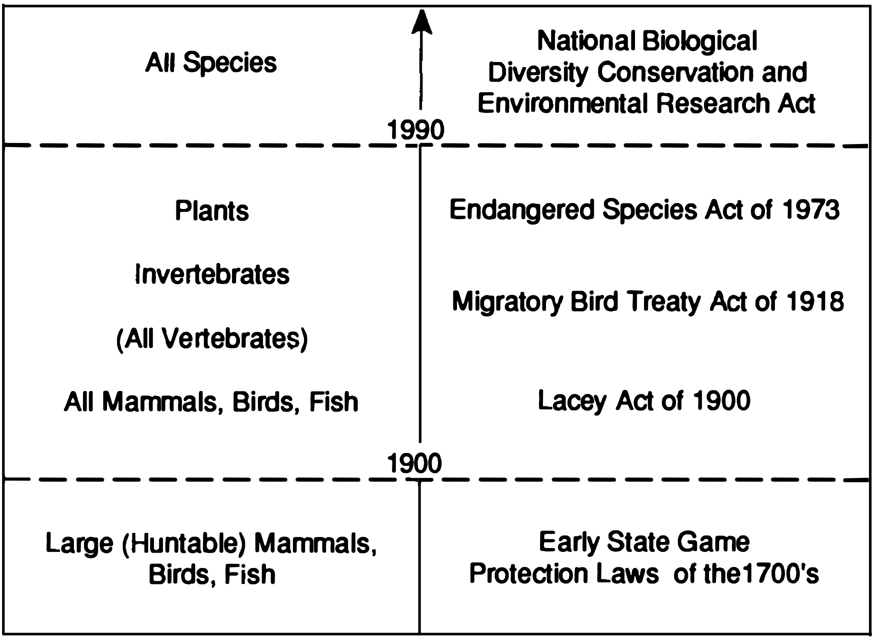

Figure 1. Evolution of concern for species groups in the United States.

decimation of public and private forests. Currently, proposed legislation related to gene conservation is a reaction to an increased awareness of both the value of and threats to genetic diversity (Schonewald-Cox et al. 1983).

The recent concern and proposed legislation thus follows in this tradition. Loss of species and the ecosystems of which they are a part is proceeding at an unprecedented rate. The threats to life are more imminent, insidious, and global than in the past; thus, a more holistic concern and response has developed.

Amidst all this concern over biological diversity in general, rangelands have received little attention in this country. Major attention has focused upon loss of biodiversity in forests, particularly on the liquidation of ancient forests (Thomas et al. 1988). Yet biological diversity on rangelands is just as threatened. Because the threats are typically more subtle and insidious on rangelands, they receive less attention. Ehrlich (1989a) has pointed out that there was no reason for our ancestors to evolve a capacity to detect gradual environmental trends. Our rangelands suffer from this myopia.

Threats to Biological Diversity on Western Rangelands

Biodiversity on western rangelands is threatened by many factors, including diversion and pollution of water, agricultural and urban development, livestock grazing, mineral extraction, habitat fragmentation and global warming.

All Ecosystems	National Biological Diversity Conservation and Environmental Research Act
1990	
Rangeland	Federal Land Management and Policy Act of 1970
Forestlands	National Forest Management Act of 1976
Coastal Areas	Marine Protection Research and Sanctuaries Act of 1972
Rivers	Wild and Scenic Rivers Act of 1964
Wilderness	Wilderness Act of 1964
Wildlife Sanctuaries	Fish and Game Sanctuary Act of 1934
Grazing Lands	Taylor Grazing Act of 1934
1900	
Timberlands	Forest Reserve Act of 1891

Figure 2. Evolution of concern for ecosystems in the United States.

Water is in limited supply in the West, but it is in great demand for human activities. Thus, some of the earliest and most pervasive effects on biological diversity have been the result of diversion of water from natural systems to human activities. Damming of rivers, lowering of water tables, degradation of riparian areas, and usurpation of springs for livestock have had a major impact on the biota of the West (Hunt 1988).

The impact of livestock grazing on biological communities in the West has received much attention. However, most attention has focused on competition between livestock and large, huntable, or otherwise economically valuable animal species (Wagner 1978). Only in the last two decades have some of the less obvious effects of livestock grazing been identified or documented. Examples of these effects include: (1) transmission of diseases from livestock to native species, such as from domestic sheep to bighorn sheep (Goodsen 1983), (2) decline of bird species due to loss of cover from livestock grazing (Brown 1978) and (3) competition between livestock and smaller native herbivores such as desert tortoises (Berry 1978). The influence of livestock grazing on plants has been similarly widespread and dramatic at times.

However, most of the attention and research has focused on the community level. Very little is known about effects on, for example, rare plants. Furthermore, the impact of livestock grazing on invertebrates or lower plants is rarely considered.

These few examples represent only a small sample of the impacts of introducing over 300 million AUMs per year of livestock grazing onto western rangelands in a period of a little over 100 years. Wagner (1978) has concluded that livestock grazing is certainly the most ubiquitous influence on the biota of the West, and that while some changes are drastic and obvious, others are subtle and not easily recognizable, even by professionals. Since livestock grazing remains on of the most common and widespread uses of western rangelands, and since impacts of such grazing on biological diversity are so poorly understood, livestock grazing must be considered as one of the primary threats to biological diversity.

Other threats include the myriad of activities on the arid lands of the West, particularly mining, agricultural development, recreation, urban/suburban expansion, and the development of transmission and transportation corridors. The threats to biological diversity from these activities are too numerous to document here, except to note that a common result is fragmentation of habitat. Fragmentation of large blocks of continuous habitat into smaller isolated parcels that cannot support viable populations of plants or animals can cause local extirpation or eventually extinction (Wilcove 1987).

Finally, impacts from future global warming could result in substantially altered climatic regimes in the West, resulting in increased extinctions (Murphy and Weiss 1988). Of primary importance, in considering impacts of global climate on rangelands, is that such changes will likely be synergistic with other impacts (Peters 1988). For example, rangelands that are fragmented and heavily grazed, with deteriorated riparian areas and watersheds, will likely suffer more loss of biological diversity from increased temperatures and decreased precipitation.

Current Programs on Western Rangelands

Blockstein (1989) has suggested that any program for conservation of biological diversity should encompass four elements: (1) designation and management of protected areas; (2) utilization of semi-natural areas, (3) recovery of endangered species and degraded ecosystems; and (4) research. What is the status of such efforts on rangelands of the West?

Designation and Management of Protected Areas

The goal here is to form a preserve system through the designation of representative samples of the ecosystems and communities of the West. This has been attempted in three ways. The first and oldest approach was by designation at the largest scale with the national parks and monuments and certain larger wildlife and game refuges. Secondly, the designation of wilderness areas and wild-and-scenic rivers within other primarily federal lands has been an active program recently. Finally, at the smallest scale, protection can take the form of natural areas, research natural areas, refuges or areas of critical environmental concern (ACECs).

Current preserve systems in the U.S. are of limited effectiveness by themselves because most such areas were not established to preserve biological diversity (Blockstein 1989). This is well illustrated on western rangelands. Most of the national parks and monuments of the non-forested West—parks such as Grand Canyon, Zion, and Capitol Reef—were designated because of their spectacular geologic features. Similarly, until recently most designation of wilderness areas and wild rivers was based upon desirability for primitive recreation such as backpacking and canoeing. This has resulted in a disproportionate number of alpine wilderness areas and white-water wild-and-scenic rivers. At the natural area level, there is similar evidence. For example, Williams and Campbell (1988) point out that even though 191 ACECs have been designated by BLM to protect natural values (including both plants and animals), the program has still been inconsistent. However, some positive signs of change are evident. The Bureau of Land Management (BLM) has systematically compared wilderness study areas (areas being studied for inclusion in a national wilderness system) to determine if they represent Bailey-Kuchler vegetation types (one system of classifying potential natural vegetation) not currently designated as wilderness. At latest count BLM wilderness study areas represent 111 of 138 Bailey-Kuchler types in the West, many of which are not now in any wilderness system (Cooperrider 1989). Furthermore, BLM is conducting a parallel study to determine the representation of Bailey-Kuchler types within ACECs.

A second major problem with the preserve system in the West is that many preserves are not large enough to maintain viable populations of target species, much less self-sustaining ecosystems. Our oldest and largest national park in the West, Yellowstone, is not large enough to contain viable populations of many species, thus necessitating the need for management based upon the "Greater Yellowstone Ecosystem" (Clark and Zaunbrecher 1987).

Finally, no preserve is truly pristine or totally protected. Air pollution, exotic plants and animals, polluted water and other "non-natural" elements cross preserve boundaries as readily as they cross county lines. Furthermore, global warming as well as other forms of global change, will affect all areas equally, resulting in what has gloomily been termed "the end of nature" (McKibbin 1989).

Because of the limitations of preserves and most importantly because of the small probability that many new large preserves are likely to be designated, management of the lands surrounding the preserves, the semi-natural areas, is becoming of increasing importance (Salwasser 1987, Thomas and Salwasser 1988).

Management of Seminatural Areas

On western rangelands, some of the greatest opportunities for conserving biological diversity lie in the management of semi-natural areas. The relatively recent settlement of the West and the high percentage of lands still in public ownership has resulted in a large amount of public land with limited loss of biological diversity (Cooperrider 1989). Of particular importance and potential on western rangeland areas are the BLM lands, which provide biological continuity to what would otherwise be isolated islands of parks and refuges. However, until very recently, conservation of biological diversity on semi-natural rangelands of the West, both public and private, has been a lower priority than commodity production.

Ecological Recovery

Ecological recovery efforts are underway at both the species level and community level. At the species level, many efforts are underway in the West which are adequately publicized and documented elsewhere. However, in the West as elsewhere in the world, the species approach to conserving biological diversity in the absence of habitat conservation is likely to fail (Hutto et al. 1987).

In spite of widespread deterioration of many western rangelands, restoration at the community level has been limited in scope and narrow in purpose. For example, the principal purpose of most rangeland rehabilitation projects has been restoration of livestock forage. Such projects typically result in reduction of plant and animal species diversity.

A major exception to this pattern is the efforts to rehabilitate riparian areas in the West. Although riparian areas are some of the most important areas for wildlife and some of the most damaged, there have been some successes in restoring these areas (Prichard and Upham 1986). These efforts are being funded and promoted in BLM and other agencies because of the recognition that the biological diversity of these areas is important for numerous amenities and commodities (Cooperrider 1989). Few other plant communities have received such attention, much less, successful rehabilitation.

Research

Blockstein (1989) has emphasized the need for scientific research to address questions related to biodiversity. Although much research has been conducted on rangelands, until recently much of this research has focused on management for livestock production. By comparison, research relevant to conservation of biological diversity on rangelands has been quite limited, with most advances in our knowledge being fortuitous. For example, much money has been spent on research into ways to control or extirminate native shrubs and trees such as sagebrush, juniper and pinyon pine. These species are alleged to limit production of livestock forage. Yet, very little research effort has focused on the ecology of these plants and the biotic communities of which they are keystone species. Similarly, research on ways to control exotic plants has typically focused on high technology treatments such as herbicide treatments rather than on the ecology of plant invasions.

Closely related to the need for research is the need for inventory and monitoring. Unfortunately, inventory of the biological resources has never been completed for most rangeland areas of the West. Furthermore, because of a lack of rigorous monitoring, much useful information on rangeland management, including successful efforts to conserve biological diversity, has been lost through lack of adequate documentation.

New Approaches

Considering the many threats, the risk of catastrophic losses of biodiversity on western rangelands is great. Many of the rangelands of the Great Basin are already showing symptoms in the form of widespread invasion of exotic plants. Desertification, or serious degradation of rangelands, is not a phenomena limited to developing countries (Savory 1986).

On the other hand, there are opportunities to have an exemplary program for conservation of biological diversity. Older approaches to conservation will need to be continued and even strengthened. There are still many areas in the West that need designation and protection as parks, wilderness, natural areas or ACECs. Similarly, endangered species programs need more support, as do land rehabilitation efforts.

Furthermore, the longstanding need for completing an inventory of the biological resources of western rangelands will be prerequisite to initiating many programs.

More importantly, some new approaches to conservation, involving both the government and private sector, are needed. Some successful newer approaches to conservation biology in the West have the following characteristics (Cooperrider 1989): (1) recognition of the complexity of ecosystems and ecosystem processes, (2) recognition of the need for planning and management at the ecosystem or regional level (to complement other levels), (3) utilization of a variety of disciplines in studying and solving problems, and (4) unprecedented level of coordination and cooperation between and public and private agencies and other interested parties. Future successful approaches to conservation biology will likely share these characteristics.

Many human-caused losses of biological diversity have been the result of simplified notions of ecosystems and ecosystem processes. To reverse this process we need to recognize the complexity of ecosystems, even though knowledge of how they work may be very slow in coming and will always be incomplete. Recognition of this complexity will reinforce the need for interdisciplinary approaches to resource problems. Appreciation of the complexity of ecosystems will similarly discourage the use of quick-fix, high technology solutions such as use of herbicides in the absence of knowledge of long term impacts.

Recognition of the complexity of rangeland ecosystems and threats to them leads to the need for research into basic ecosystem processes. Current ecosystem research suggests that ecosystems may be more easily upset by human perturbations than previously though (Perry et al. 1989), and that virtually unstudied elements such as microrhizal fungi may be keystone species on rangelands (Trappe 1981). There has been much research on how to maintain a few ''desirable'' forage species, and prevent or eradicate certain exotic or weedy ''undesirable'' species. However, until fairly recently, little research has focused on effects of grazing on rare plants or more generally on how to maintain species diversity on grazed rangelands. There has been particular interest and study recently of the impact of livestock grazing on riparian plant communities and the fauna they support. However, impact of livestock grazing on plant species or plant genetics on this or most other communities is virtually unstudied and unknown.

We need to support more research on how to maintain biological diversity on rangelands. In conjunction with this effort we need a program of systematic inventory and monitoring of the biological diversity of such rangelands. Finally, we need to take advantage of the local peoples' knowledge of ways to manage areas with minimal impact on biological diversity (Dasmann 1985). This is a concept often mentioned in relation to Third-World countries, but typically neglected in our own backyards.

Knowledge of the complexity of ecosystems reinforces the need for a degree of planning at the ecosystem, landscape or even regional level. Since many ecosystem processes, such as disturbance cycles and succession occur at the ecosystem or landscape level, planning for conservation of biological diversity must be done on this scale as well as others (Noss 1983). As pointed out earlier, most preserves in the West are too small from the point of view of conserving biological diversity. Therefore, they must be managed in conjunction with surrounding semi-natural lands. This will require planning at the regional level. The ''gap analysis'' program being pioneered in Idaho represents the sort of regional or landscape level of inventory and planning that is needed (Scott et al. 1987).

Effective programs on semi-natural areas will require that they are managed with a co-equal objective of conserving biological diversity and resource production. Equally important, management programs for these areas must be developed in conjunction with programs for the imbedded preserves. This concept is central to the concept of "multiple use modules" as proposed by Noss and Harris (1986), or the biosphere reserves (Hough 1988). At the present time such planning and management is rare. Preserves are often managed as if they existed in isolation, and surrounding semi-natural lands are exploited for resource production at the expense of the substantial natural diversity they harbor.

Livestock grazing is of course the most widespread use of semi-natural rangelands. The debate over the limits of tolerance to livestock grazing on western rangelands is highly polarized, with some advocating removal of livestock from all public lands and others minimizing the impacts or even suggesting the benefits to biological diversity from livestock grazing. Arguments abound about impacts of numbers, class of livestock, distribution and timing of grazing.

The criteria of sustainability should provide the guidance needed to resolve this question. If livestock can be grazed in such a way as to preserve the biological diversity and ecological integrity of the landscape, then the reasons for opposing such grazing become limited. There are many areas that have been grazed by livestock for many years with no apparent or measured loss of biological diversity. However, for many areas of the West, the premise that livestock can be grazed without loss of biological diversity remains untested and unproved. In other areas we know that livestock grazing is not compatible with maintaining biological diversity. for example, we now know that domestic sheep grazing within bighorn sheep range will result in catastrophic dieoffs of the bighorn (Goodsen 1983).

Since landscapes and ecosystems typically comprise lands managed by a diversity of ownerships, implementation of programs will require unprecedented levels of cooperation between public and private agencies. Managers of preserves must shed elitist attitudes that their pristine islands are not connected to the rest of the world and can be managed in isolation. Similarly, the managers and users of the semi-natural rangelands must shed their commodity-oriented biases and recognize that maintenance of a landscape and its biological diversity is the foundation for continued resource production. Finally, private individuals and organizations must recognize that both the preserves and the surrounding areas are important to their health and welfare, physically and spiritually.

Because of the relatively large amount of public, primarily federal, land in the West, the leadership role of the federal government would appear to be of prime importance. Although leadership will be needed, history has shown that few programs lacking the support of the local people are successful in the long run.

The Importance of Awareness

This leads to the central importance of increased awareness of the importance of biological diversity. Genes, species, ecosystems and the processes that maintain them, are the basic components of sustainable systems (Maser 1988). As these components are lost, ecosystems begin to unravel and eventually cease to function. Sustainable (eco)systems are required for sustainable economies—in spite of the blind economists who describe economic cycles with no external inputs—the economists equivalent of the perpetual motion machine (Ehrlich 1989b). Thus, sustainable (eco)systems are the basis of sustainable societies (Jacobs 1986). Given this situation, preservation of biological diversity on rangelands is of equal importance to the rancher as to the birdwatcher or hunter.

A successful program for conservation of biological diversity will require awareness of this relationship between biological diversity and sustainability. It will require awareness by all parties—politicians, bureaucrats, ranchers, landowners, conservationists and citizens. Finally, it will require concern for sustainability and action based upon such awareness and concern.

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Effects of Specialized Grazing Systems on Waterfowl Production in Southcentral North Dakota

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The recent decline in numbers of several waterfowl species (Canadian Wildlife Service and U.S. Fish and Wildlife Service 1986, U.S. Fish and Wildlife Service and Canadian Wildlife Service 1988) and poor nesting success indicates that there is insufficient production of ducks in the prairie pothole region to maintain populations at desirable levels (Klett et al. 1988). About 50 percent of the ducks in North America are produced in the prairie pothole region and about 95 percent of the production occurs on private lands (Smith et al. 1964). Thus, a major effort to reverse the decline in duck numbers should emphasize the use of new and improved management techniques on private lands, particularly the use of new rangeland grazing systems.

Numerous studies have evaluated the effects of grazing on duck production (Kirsch et al. 1978) in North America. However, most of these evaluations were designed to compare differences of duck production between grazed lands and idle lands or among different land uses. Also, nearly all of the earlier studies of grazing effects involved seasonlong grazing treatments with occasional differences in grazing intensities (Kirsch 1969). Seasonlong grazing has been shown to be detrimental to production of most upland nesting birds (Kirsch et al. 1978) and also to maximum livestock production (Kirby and Nyren 1988, Barker and Nyren 1988). During the 1970s and 1980s considerable agriculture research was directed at increasing red meat production on private lands via the implementation of various kinds of grazing systems. However, there were fewer evaluations of the effects of various grazing systems on wildlife (Peek and Dalke 1982). To help fill this information void, a study of livestock and waterfowl relationships was initiated in 1982 on the Central Grasslands Research Center, an experimental facility of North Dakota State University, Fargo, North Dakota.

Our study objectives were (1) to determine the effects of complementary, seasonlong, short duration, switchback and twice-over rotation grazing treatments and an idle treatment on upland vegetation characteristics, duck nest densities, nest site selection and nesting success, (2) to compare livestock production on these same grazing treatments and (3) to determine if any of the grazing systems benefited both upland nesting ducks and livestock production more than the others.

Study Area

Research was conducted on the Central Grasslands Research Center (Nyren 1986), approximately 41 miles (65 km) southwest of Jamestown, North Dakota, within the Missouri Coteau physiographic region. The Center occurs in Sections 14, 22, 23, 24, 25, 26, 36 T138N, R70W; Section 1, T137N, R70W; Sections 30, and 31, T138N, R69W; and Section 6, T137N, R69W (Lura 1985). Nesting studies were carried out on Sections 14, 24, 25 and 31. The Center is generally characterized by ''hummocky,'' irregular, rolling plains containing numerous wetlands and potholes and a poorly integrated natural drainage system (Lura 1985). At maximum capacity, ephemeral, temporary, and seasonal wetlands (Stewart and Kantrud 1971) comprise approximately 9 percent of the total station area (Lura 1985). Wetlands are essential for attracting waterfowl. The idle area and switchback grazing system contained 14 and 10 percent wetland, respectively, compared to 6 percent on the twice-over rotation, 4 percent on the short duration, 4 percent on the complementary and 4 percent on the seasonlong grazing treatments when basins were at full capacity.

Vegetation typical of northern mixed grass prairie is found on the Center (Whitman and Wali 1975, Lura et al. 1988, Barker and Whitman 1988, Küchler 1964). The nesting habitat was comprised of five range site types of which 41 percent was overflow, 7 percent was wetland, 49 percent was silty, 2 percent was thin upland and 1 percent was shallow-to-gravel. Overflow sites also included wet meadow areas. The complementary and twice-over rotation grazing systems also contained 50.0 and 10.5 percent reseeded cover, respectively, by land area.

Climatic Conditions

North Dakota has a continental climate characterized by warm summers and cold winters. January is the coldest month and July is the warmest. The mean annual precipitation for the past 37 years on the study area was 17.6 inches (44.7 cm), with 80 percent falling between April and September. The annual precipitation was 23.0 (58.4), 18.9 (48.0), 19.8 (50.3), 17.9 (45.6), 27.2 (69.1), 17.9 (45.6), 7.7 (19.5) and 18.4 inches (46.7 cm) in 1982 through 1989, respectively. A drought began in September 1987 that greatly reduced range forage production in 1988. The average length of the freeze-free period for the area is 120–125 days (Ramirez 1972).

Grazing Treatments

Five grazing treatment areas and a non-grazed, idle treatment area were evaluated in this study. All treatment areas were contiguous, with similar topography and equal chance of predator influences. Extensive details of annual cattle herd size, stocking rates, dates of rotation, grazing dates and grazing system schematics were presented for each treatment during a series of studies (Messmer 1985, Hertel 1987, Sedivec 1989). The idle treatment in Section 24 consisted of 320 acres (130 ha) that was last grazed in 1979. Fifty acres (20 ha) were mowed in September 1985 and all 320 acres (130 ha) were mowed in mid-July 1988, a drought year.

Section 25 (259 ha) was divided equally in 1982 into seasonlong and short duration grazing treatments. The seasonlong treatment consisted of one 320 acre (130 ha) pasture and was grazed by one herd at a recommended stocking rate (U.S. Soil Conservation Service 1984) averaging 0.68 AUM/acre (1.7 AUM/ha) since 1984. Livestock were free to graze any area within the seasonlong pasture. The 320-acre (130 ha), short duration grazing treatment consisted of eight 40-acre (16.2 ha) pastures, each grazed by one herd at an average stocking rate of 1.01 AUM/acre (2.5 AUM/ha) since 1984. Each of the eight pastures in the short duration grazing treatment were grazed for 5 days during each of four rotations during the grazing season, with 35 days rest between rotations. In 1989 the grazing period between rotations varied, beginning with 3 days and followed by 4 days, 6 days and 7 days per rotation. The number of days rest ranged from 21 on the first rotation to 49 on the last rotation.

Section 31 was divided equally into two replications of the twice-over rotation grazing treatment. In 1983 and 1984 each replication consisted of three 80-acre (32.4 ha) pastures and were grazed by one herd at an average stocking rate of 0.93 AUM/acre (2.3 AUM/ha), respectively. Each pasture was grazed for 28-day periods and then rested for 56 days during each of two rotations. In 1985 through 1989, each replication consisted of four 80-acre (32.4 ha) pastures which were each grazed by one herd at an average stocking rate of 1.0 AUM/acre (2.4 AUM/ha). Each pasture was grazed for 20 days and then rested for 60 days during each of two rotations.

In 1987 two replications of a switchback grazing treatment were implemented on a 160-acre (64.8 ha) plot in Section 30. Each replication consisted of two 40-acre (16.2 ha) pastures and each were grazed by one herd at an average stocking rate of 1.1 AUM/acre (2.6 AUM/ha) in 1987 and 1989 and 0.7 AUM/acre (1.6 AUM/ha) in 1988. Each pasture was grazed for 20-day periods and then rested for 20 days during each of four rotations.

In 1985 a complementary grazing treatment was implemented on 170 acres (68.8 ha) of Section 14. This treatment consisted of three tame pastures and one native pasture. Livestock began grazing in a 30-acre (12.1 ha) crested wheatgrass (*Agropyron desertorum*) pasture and were then rotated sequentially to an 80-acre (32.5 ha) native pasture, a 30-acre (12.1 ha) Russian wildrye grass (*Elymus junceus*) pasture, and a 30-acre (12.1 ha) altai wildrye grass (*Elymus angustus*) pasture. On the complementary grazing treatment stocking rates averaged 1.0 AUM/acre (2.4 AUM/ha) for all years, 1985–1989, except 1988. Cattle stocking rates were reduced by about 40 percent on all grazing treatments in 1988, a drought year.

Methods

Nest Searches

Nest searches were conducted between 1 May and 15 July, 1984 through 1989. Four searches were made at three-week intervals in 1984, 1987, 1988, and 1989. Three nest searches were conducted at four-week intervals in 1985 and 1986. Five nest searches were conducted at 18-day intervals between 15 April and 10 July in 1983. Nest searches were performed between 7:00 a.m. and 1:00 p.m., since that time period has the highest probability of hens being on their nests (Klett et al.

1986). Nests were found by dragging a five-sixteenths inch (8 mm diameter), 100 foot long (30.5 m) chain between two 200 cc all terrain cycles according to methods described by Higgins et al. (1969, 1977).

Each site from which a duck flushed was considered a nest if at least one egg was present in a scrape. Data recorded at each nest site included date, treatment, duck species, number of eggs, stage of embryo development (Weller 1956) and dominant plant species. Visual obstruction readings, modified from Robel et al. (1970) were taken at each nest site. All nests were marked by placing a small, red, surveyor's flag at 12 feet (4 m) distance. Nest sites were also plotted on aerial photographs to aid relocation every 7–10 days to determine their fates. Nests in which at least one duckling hatched and left the nest site were classified as successful.

Vegetation Sampling

Visual obstruction readings to the nearest inch (0.25 dm) (Robel et al. 1970) were used to determine a height and density index of the vegetation at each of the management treatment areas. Readings of heights of 100 percent obstruction were taken along permanent transects. These transects were proportionately allocated (Messmer 1985) on the basis of range sites present within each treatment (Table 1). Each transect lay in a north-south direction from fenceline to fenceline and contained 25 stations 30 paces apart. Four visual obstruction readings were obtained per station twice each field season; once about 25 April for residual vegetation and once about 25 May prior to grazing but after the onset of new vegetative growth.

Estimates of Nest Success

Daily nest survival rates were calculated according to the Mayfield (1961, 1975) method as modified by Johnson (1979). Nests were excluded from analysis if nest abandonment occurred due to search activities, if nests were destroyed by nest search activities or if we were unable to relocate nests.

Mayfield nest success was calculated from daily nest survival rates following Johnson (1979). Thirty-five days of exposure was used for computing Mayfield nesting success for redheads (*Aythya americana*) and mallards (*Anas platyrhyncos*), 34 for blue-winged teal (*A. discors*), gadwalls (*A. strepera*), American wigeon (*A.

Table 1. Percentages of various range sites for five grazing treatments and one idle treatment at the Central Grasslands Research Center, North Dakota.

	Size		Range site percentages				
Treatment	Acres	(ha)	Overflow[a]	Silty	Wetland[b]	Other sites	Seeded
Seasonlong	320	(130)	43.5	49.9	3.1	3.5	—
Short duration	320	(130)	49.6	46.3	4.1	—	—
Switchback	160	(65)	40.3	49.5	10.2	—	—
Twice-over rotation	640	(259)	20.7	59.0	6.3	3.5	10.5
Complementary	170	(69)	18.9	25.0	4.2	1.9	50.0
Idle	320	(130)	75.2	8.8	14.1	1.9	—

[a]Overflow range sites include wet meadow sites.
[b]Wetland percentages include basins at 100 percent capacity.

americana), green-winged teal (*A. crecca*), lesser scaup (*Aythya affinis*) and northern shovelers (*Anas clypeata*), and 33 for northern pintails (*A. acuta*). Total nesting density for all duck species combined was obtained from survival rates of individual species weighted by each species nesting density.

Livestock and Forage Performance

Forage production and range utilization estimates were determined annually on all treatment areas. Portable cages 2.5 by 5 feet (0.8 by 1.5 m) were placed on plots in each treatment and paired with grazed plots, all of which were clipped throughout the grazing season. The initial clipping plus growth in the cages were used to estimate forage yield. Forage disappearance weights from grazed plots were used to determine percent utilization.

Livestock were randomly sorted and weighed on and off grazing treatments to obtain production values for average daily gain (ADG) and average seasonal (about 160 days) gain (AG) (pounds/acre; kg/ha) for calves. Additional weights were taken at 84 days into the grazing season and every 28 days thereafter. The experimental livestock breed consisted of a Hereford-Angus-Gelbvieh cross.

Statistical Treatment

Mayfield nesting success and number of ducklings hatched per 100 acres (40.5 ha) were tested for significant ($P < 0.05$) main effects and two-way interaction using analysis of variance and then fit in a model including only significant effects. Where significant differences were detected, a Waller-Duncan T-test was used to separate the means.

Results

Nest Numbers

Nine duck species were found nesting on the station. Of the 1,601 duck nests found, 36.1 percent were blue-winged teal, 22.9 percent gadwall, 17.9 percent mallard, 13.1 percent northern pintail, 5.6 percent northern shoveler, 1.9 percent American wigeon, 1.6 percent lesser scaup, 0.7 percent green-winged teal and 0.2 percent redhead.

Range Site Selection

Nest site selection was determined for overflow, wet meadow, silty, thin-upland, and shallow-to-gravel range sites, and reseeded grasslands within each treatment. Generally, most blue-winged teal and lesser scaup nested nearest to water, whereas mallards, northern pintails, gadwalls, northern shovelers, and American wigeon nested near water and also as far away as a mile (1.6 km) from water. Of 1,119 nests, 77.8 percent were initiated in overflow range sites, 19.3 percent in silty, and 2.9 percent in the other range sites (Table 2). The importance of overflow range sites to duck nesting within mixed-grass prairie grasslands was illustrated by the fact that these sites comprised only 41.4 percent of the upland area but contained 77.8 percent of all nest initiations.

Table 2. Comparison of duck nest site selection among range sites at the Central Grasslands Research Center for all years 1985 through 1989.

Species	Number of nests	Percentage of nests n range sites		
		Overflow	Silty	Other
Mallard	210	93.0	5.0	2.0
N. Pintail	147	73.0	23.8	3.2
Gadwall	285	84.3	11.8	3.9
Blue-winged teal	357	68.1	29.5	2.4
Others	120	74.5	20.0	5.5
Total	1,119	77.8	19.3	2.9

Residual Cover

The idle treatment averaged significantly more ($P < 0.05$) residual and early green-up cover prior to grazing than any of the grazing treatments for 1983 through 1988 (Table 3). Mean visual obstruction readings among the grazing treatments averaged highest on the switchback grazing treatment, but barely so.

Nesting Density

Nest densities were highest in the idle treatment in 1983, 1984, 1985 and 1988; in the short duration grazing system in 1986, and in the switchback grazing system in 1987 and 1989 (Table 4). Nest densities in the idle area ranged from 2.4 times greater than the grazing treatments in 1983 to an equal density in 1987. For all seven years, the idle area nest densities averaged 1.6 times greater than any of the grazing treatments.

Among the grazing systems, nesting densities were highest in the twice-over rotation grazing treatment in 1983, 1984, 1985 and 1988, in the short duration grazing treatment in 1986, and in the switchback grazing treatment in 1987 and 1989. Nesting

Table 3. Mean visual obstruction readings taken in vegetative cover on the various grazing treatments and idle area at the Central Grasslands Research Center, 1983 through 1989.

Treatment	April 25 Residual cover Visual obstruction readings		May 28 Before grazing early green-up Visual obstruction readings	
	Inches	Decimeters	Inches	Decimeters
Seasonlong[a]	2.9	0.7	5.6	1.4
Short duration[a]	2.5	0.6	5.6	1.4
Twice-over[a] rotation	2.5	0.6	6.0	1.5
Complementary[b]	2.4	0.6	6.0	1.5
Switchback[c]	3.2	0.8	6.9	1.8
Idle[d]	5.5	1.4	11.3	2.9

[a] = 7 years.
[b] = 5 years.
[c] = 3 years.
[d] = 6 years of annual measurements.

Table 4. Density of nests found per 100 acres (40.5 ha) on the various grazing treatments and idle treatment at the Central Grasslands Research Center in 1983–1989.

	Density of nests per 100 acres (40.5 ha)							
Treatment	1983	1984	1985	1986	1987	1988	1989	Avg.
Seasonlong	4.3	7.1	3.7	5.3	24.4	11.9	10.6	9.6
Short duration	9.0	15.4	5.0	11.7	27.8	14.4	7.8	13.0
Twice-over rotation	11.9	15.6	7.6	9.6	18.6	15.9	12.8	13.2
Complementary	—[a]	—[a]	4.1	4.7	10.0	3.5	5.9	5.6
Switchback	—[a]	—[a]	—[a]	—[a]	30.3	13.0	13.8	19.0
Idle area	22.1	26.7	10.4	11.1	23.3	18.6	—[b]	18.7

[a]Treatment was not in operation in these years.
[b]Hayed during drought year.

densities varied with the amounts of overflow range sites, residual vegetation, wetland availability and treatment area free of livestock during the critical nesting period.

Nesting Success

Nesting success was significantly higher ($P < 0.05$) on the twice-over rotation grazing treatment than on all the grazing treatments and the idle treatment, except for the switchback treatment, 1983–1989 (Table 5). Nesting success on the idle area ranged from 6.6 percent in 1983 to 16.3 percent in 1985 and 1987, but was always exceeded by productivity on at least one grazing treatment in every year. Nesting success on the twice-over rotation grazing treatment was consistently higher than on the idle area, ranging from 2.3 times greater in 1984 to 6.2 times greater in 1986. Nesting success was greater in short duration and seasonlong grazing treatments than the idle area in all years except 1984.

Cowardin et al. (1985) suggested that a Mayfield nesting success of 15.2 percent was needed to maintain a waterfowl (mallard) population. According to this criterion, the idle area only maintained a population in two of six years, the twice-over rotation grazing treatment in seven of seven years, the short-duration grazing treatment in six of seven years, the seasonlong grazing treatment in three of seven years, the

Table 5. Percentage of Mayfield duck nesting success occurring on the grazing treatments and idle treatment at the Central Grasslands Research Center, 1983 through 1989.

	Percentage nesting success							
Treatment	1983	1984	1985	1986	1987	1988	1989	Average[a]
Seasonlong	12.0	11.7	40.3	52.8	41.3	14.7	13.3	26.6 wx
Short duration	22.0	1.0	17.9	60.8	25.4	22.7	36.2	25.6 xy
Twice-over rotation	17.0	31.4	54.6	43.2	49.3	34.0	16.4	34.7 w
Complementary	—	—	8.0	20.8	8.7	3.3	3.2	8.8 xyz
Switchback	—	—	—	—	29.8	17.4	11.9	22.7 xyz
Idle area	6.6	13.6	16.3	7.0	16.3	7.0	—	11.3 yz

[a]Means with the same letter are not significantly different ($P > 0.05$).

complementary in one of five years and the switchback grazing treatment in two of the three years it was in operation.

Cattle Effects

The average beginning date of grazing on the station was May 28 for 1983 through 1989. Over 57 percent of 1,198 nests found during the seven years were initiated before grazing began (Table 6). After the onset of grazing, 27.7 percent of duck nests found were initiated in idle pastures, 12.9 percent in pastures when cattle were present and 2.1 percent in pastures after cattle began rotations. Sixty-five percent of the clutches initiated after the onset of grazing were initiated on pastures free of cattle at the time.

Rest intervals between rotations varied among the grazing treatments. The twice-over rotation grazing treatment allowed for 60 days rest between rotations, leaving a high percentage of land with no cattle present during the critical nesting period. About 37 percent of nests found on the twice-over rotation grazing treatment were initiated in pastures when cattle were absent (Table 6). The short duration grazing treatment allowed 35 days rest between rotations and 29.2 percent of the nests in this treatment were also found in ungrazed pastures. The switchback grazing treatment allowed 20 days of rest between rotations and 12 percent of the nests found in this treatment were in ungrazed pastures.

Duck Production

Although duck nest densities were highest on the idle area in four out of six years (Table 4), it produced fewer successful nests and ducklings per 100 acres (40.5 ha) than four of the five grazing treatments (Table 7). Overall, the twice-over rotation, short duration, switchback grazing and seasonlong treatment areas produced more successful nests and ducklings per 100 acres (40.5 ha) than the idle and complementary grazing treatment areas. However, only production from the switchback treatment averaged significantly greater ($P < 0.05$) than on the idle treatment, 1985–1989.

Table 6. Percentage of nests initiated on each entire grazing treatment area before the grazing season, in ungrazed pastures, while cattle were present and on pastures after cattle were rotated, for all years, 1983 through 1989.

Grazing treatment	Total nests found	Percentage of nest initiations: Before the grazing season	In ungrazed pastures	In pastures while cattle were present	In pastures after cattle were rotated
Seasonlong	216	61.1	—	38.9	—
Short duration	294	67.7	29.2	1.8	4.9
Twice-over rotation	549	54.9	37.2	6.9	0.9
Complementary	48	0.0[a]	75.0	25.0	0.0
Switchback	92	64.1	12.0	17.4	6.5
Average of all treatments	240	57.1	27.9	12.9	2.1

[a]Grazing begins about 30 days earlier on this treatment than on the others.

Table 7. Mean annual production of forage, livestock and ducks on grazing and idle treatments at the Central Grasslands Research Center, North Dakota, 1985–1989.

			Mean Annual Production			
			Forage	Calf gains[a]	Ducks	
Treatment	Years averaged	Percentage utilization	lbs/acre	lbs/acre	Successful nests/ 100 acres (40.5 ha)	Ducklings[b] hatched/ 100 acres (40.5 ha)
Seasonlong	5	54	2,863	44	4.6	49 u
Short duration	5	62	2,732	61	5.3	59 tu
Twice-over rotation	5	54	2,580	62	6.6	63 tu
Complementary	5	59	1,962	59	1.4	12 v
Switchback	3	57	3,226	61	7.7	65 t
Idle	4	0	—	0	5.9	47 u

[d]Daily calf gains averaged about 2.2 lbs/day (1.0 kg/day).
[e]Means with the same letter are not significantly different (P > 0.05).

Livestock and Forage Performance

Average daily calf gain for the years 1985 through 1989, approximately 2.2 lbs/day (1.0 kg/day), was similar among all grazing treatments except one. Average seasonal calf gain per acre was lower on the seasonlong grazing treatment than on the twice-over rotation, switchback, short duration, and complementary grazing treatments (Table 7) (Animal and Range Sciences Department 1982–1989). Higher stocking rates on twice-over rotation, short duration, complementary, and switchback grazing treatments account for the higher average seasonal calf gain per acre than on the seasonlong grazing treatment.

Higher stocking rates are possible on the rotational grazing treatments because of the rest periods from grazing and better livestock distribution during rotations. Forage utilization data are used by managers to justify stocking rates on various grazing treatments. Generally, range specialists and scientists suggest that only 50 to 60 percent of the vegetation should be grazed annually for proper range use. For the years 1985 through 1989, average forage utilization ranged from 54 percent on the seasonlong and twice-over rotation grazing treatments to 62 percent on the short duration grazing treatment (Table 7). Thus, proper range use occurred among all of the grazing treatments during the study.

Summary and Discussion

The nest success rates of ducks and the mean annual production of ducks on specialized grazing systems in this study were much higher than our initial expectations. With the exception of the complementary grazing treatment, the other four grazing treatments (seasonlong, short duration, twice-over rotation, and switchback) all produced ducks at an average rate of 1.5 to 2 times that believed necessary to sustain a duck population. The lowest duck production on any of the grazing treatments exceeded reported duck production on intensively-farmed tillage lands which are the other alternative land use on private lands in much of the prairie pothole region (Higgins 1977). The mean annual nest success rates for ducks in four of the five grazing treatments in this study also exceeded average rates reported from other recent duck studies (Greenwood et al. 1987, Klett et al. 1988), some of which included public lands. Our complementary grazing treatment produced the least amount of forage and ducklings while the seasonlong grazing treatment had the lowest rate of beef production and the second lowest duck production.

Although there were differences in duck nesting success rates and production of forage, beef and ducklings among the specialized grazing systems, we are reluctant to unconditionally recommend one grazing system over another for extensive use on private lands. First, in actual application, pasture sizes and distribution in specialized grazing systems on private lands would be greater than most of those used in our experiments. Second, a landowner's choice of a specialized grazing system will depend considerably on the size of the operation, the size and composition of the cattle herd(s), the land management plan already in operation, and the availability and distribution of fences and water sources. For example, a twice-over rotation system can usually be implemented with the current fences and water supplies on any ranch, whereas a short duration system usually requires more fencing, a central water supply and more labor to make the frequent herd rotations.

A major advantage of twice-over rotation, short duration, switchback and complementary grazing systems over a seasonlong grazing treatment is the elimination of grazing on pasture portions of a system until mid-June to mid-July. This provides undisturbed cover for nesting waterfowl. Once cattle are placed on a seasonlong pasture, the entire area is disturbed, either by grazing effects on cover or cattle presence. Livestock production also averaged higher on the twice-over rotation, short duration, switchback and complementary grazing systems than on seasonlong grazing. Obviously there was no livestock production on the idle area, but neither was there any waterfowl production enhancement on the idle treatment area over the grazed treatment areas, except for the complementary grazing system. The poorer duck production values on the complementary grazing treatment may have been partially due to the earlier grazing initiation on this treatment (approximately 30 days earlier) than on the other grazing treatments, to the continual presence of cattle after their entry into the system and to the 10-inch (25 cm) spacing between rows in the seeded fields; seeding at 6 and 7 inch (15 and 18 cm) spacing is the more common practice.

With the pasture and herd sizes and season of grazing used in this study, we were able to provide suitable residual cover for ducks with 50–60 percent range utilization. Residual vegetation in spring was an important component of nesting habitat for early nesting ducks such as mallards and pintails. In order to provide suitable amounts of residual cover with minimal disturbance during nest initiation, cattle grazing should not begin on North Dakota "native" rangeland until after the third or preferably fourth week in May. Late May to early June is also the suggested starting period for grazing native vegetation in North Dakota to improve range condition. Delaying initiation of grazing until about June 1 will benefit waterfowl by allowing over 50 percent of the ducks to initiate nests before grazing begins.

Greenwood et al. (1987) found that large native pastures containing western snowberry (*Symphoricarpos* spp.) and wild rose (*Rosa* spp.) provided the most important and successful nesting sites for upland nesting ducks in southcentral Canada. Western snowberry was also an important cover species at most of the nest sites in our study, and was often associated with Kentucky bluegrass (*Poa pratensis*). Overflow range sites and western snowberry were strongly associated, and were also highly selected by ducks for nesting sites. The importance of these two habitat components to nesting ducks must be considered by resource managers during grassland management planning because livestock producers often consider reduction or elimination of brush to enhance grass production. Several cool-season grasses grow well in the shade of western snowberry, and this combination provides both early and late livestock forage and wildlife cover. Thus, we recommend retention of western snowberry for duck nesting sites in native rangeland and, when possible, overflow range sites should be a consideration of habitat preservation and management strategies.

Much of the native prairie grassland of the prairie pothole region of Canada and the United States has already been converted to annually-tilled cropland, particularly those areas with the best soils. Thus, much of today's livestock and duck production occurs on poorer quality soils, many of which are marginally suited for cultivation. Boyd (1985) has pointed out the potential threat of this situation to continental duck populations. But, any chance for conversion of cropland back to grassland solely for livestock production would be entirely dependent on sustained high prices for livestock products. Since this is unlikely, the next best means to encourage landowners to retain their current grassland base is to demonstrate how higher income can be gained from these same grasslands. We believe our results demonstrate how higher beef production, which equates to higher income, can be gained from mixed grass prairie by using specialized grazing systems while simultaneously providing habitat conditions wherein ducks can also reproduce at sustainable levels.

Although we strongly support the extensive use of specialized grazing systems on private lands, we do not advocate their carte blanche use on public lands, many of which are managed specifically for wildlife production. However, specialized grazing systems may be adaptable to some joint habitat management projects involving a combination of private and public grasslands. They also provide a potential means of incentive to influence landowners not to convert Conservation Reserve program (CRP) grasslands back to cropland at the end of the contract period.

The overall importance of our findings is manifest to the current trend of emphasizing greater duck production on private lands (Canadian Wildlife Service and U.S. Fish and Wildlife Service 1986, Dornfeld and Warhurst 1988). Most private land operators are willing to implement new land-use practices for financial incentives, usually not for wildlife incentives. We believe our findings provide evidence of a means to provide private ranchers and farmers in the prairie pothole region of North America with financial incentives to retain or better manage rangelands for both beef and wildlife production.

Management Recommendations

To mutually benefit duck and cattle production on private rangelands, we recommend greater use of specialized grazing systems. We propose that this would be best achieved through proper demonstration, education and extension because if grazing systems are improperly operated or are overutilized, the long-term sustainable benefits may be forfeited for short-term economic gains. Relative to natural resources, benefits can be equated to more grassland than cropland, better wildlife habitat, less soil erosion, less chemical use, and better water quality.

For future research consideration, we recommend studies to determine thresholds for minimal and optimal amounts, heights, and distribution of western snowberry, select grass species, and spring residual cover that is necessary to provide suitable and secure nesting sites for ducks in native rangelands. We also recommend further evaluation of the response of wildlife, livestock and vegetation on rangelands where specialized grazing systems are being operated by private ranchers and farmers.

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Pronghorn/Livestock Relationships

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Introduction

Pronghorns (*Antilocapra americana*) and livestock have co-existed on western rangelands for three centuries, but few studies have analyzed their compatibility, dietary overlap, exchange of diseases, or the effects of habitat manipulation. At times, two or more herbivores enjoy a commensal relationship. At other times, the relationship may be competitive. Our objective is to review past investigations, analyze findings, and document beneficial or detrimental relationships between pronghorns and livestock on western rangelands.

The term livestock traditionally refers to cattle (*Bos* spp.), domestic sheep (*Ovis aries*), goats (*Capra hircus*), pigs (*Sus scrofa*), burros (*Equis asinus*) and horses (*Equis cabalus*). For this paper, we will limit our review to cattle, domestic sheep and horses, because they represent more than 90 percent of livestock on rangelands jointly occupied with pronghorns.

A thorough review of pronghorn-livestock relationships is not complete without discussions regarding grazing systems, animal equivalents, management plans and much more. Unfortunately, time and space for this presentation preclude covering these factors. Therefore, we have deferred these subjects to another publication we are completing this year.

Historical and Contemporary Perspectives

Pronghorn numbers, combined with those of bison (*Bison bison*), were lengendary. When Lewis and Clark crossed the continent, pronghorns numbered 30–60 million (Nelson 1925). However, between 1850 and 1900, 99 percent of the bison and pronghorn were killed by commercial and sport hunters, explorers and pioneers. At the turn of the century, the pronghorn was considered doomed to extirpation after its numbers plummeted to less than 15,000 (Hoover et al. 1959). During the twentieth century, however, pronghorns increased more than 3,000 percent. This trend still exists—the animals doubled in numbers in the last decade (Yoakum 1986). Pronghorns are next to deer (*Odocoileus virginianus* and *O. hemionus*) in abundance as big game in North America today.

Livestock were brought to western rangelands by colonists and pioneers, and many were released or escaped to become feral. The chronology of livestock numbers and distribution is well documented by Wagner (1978). Following the U.S. Civil War, large numbers of cattle were moved all the way to the Pacific. The demand for livestock forage increased 400 percent from 1870 to 1980 (Wagner 1978). At the same time, millions of acres were preempted by agriculture crops, highways, and urban and industrial development. North America changed within 200 years from a pristine, wild land to a continent of settlement and domestication. The trend continues with an expanding human population that enjoys food and fiber products from livestock.

Prior to the arrival of Europeans, pronghorns grazed the western rangelands in common with bison, wild sheep (*Ovis canadasis*), deer, and elk (*Cervus canadensis*). Wagner (1978) speculated that these endemic ungulates consumed 80–90 million AUMs (animal unit months) annually (Figure 1).

Today, wild ungulates consume approximately 5 million AUMs—less than 10 percent of historic use. Before 1850, livestock used less than 5 million AUMs forage. In 1975, land managers identified more than 100 million AUMs for cattle and domestic sheep. The greater demand for forage on western rangelands has reversed from wildlife to livestock during the past 150 years. Wagner's findings for contemporary forage demands are similar to wildlife and livestock use of public lands in southeast Oregon (Heady and Bartholome 1977, Kindschy et al. 1982). Both reports for Oregon indicate forage demand in 1975 was 88 percent for livestock and 11 percent for wildlife (Table 1).

Interspecific Relationships

Knowledge of pronghorn-livestock interactions is of value to managers, especially stewards of public lands where laws mandate multiple use. Three ways to evaluate

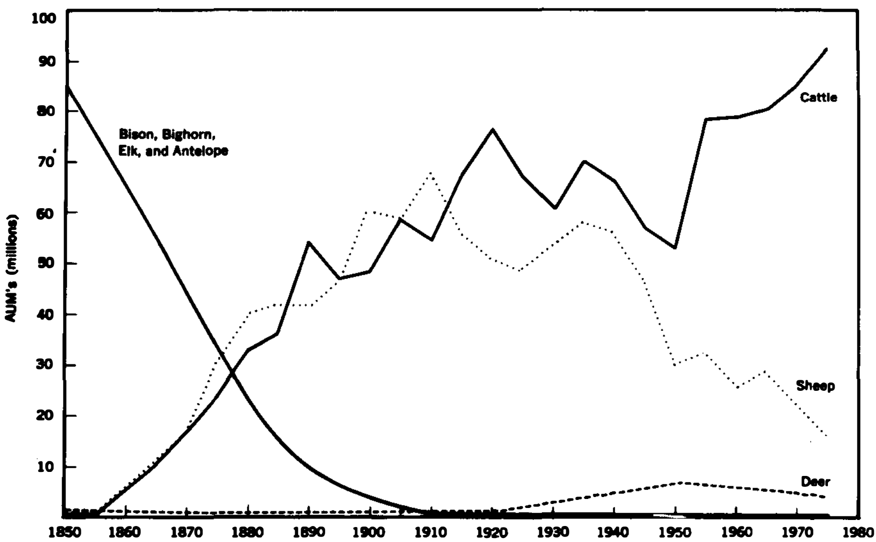

Figure 1. Conjectured demand for AUMs of forage by wild and domestic ungulates on western rangelands (Wagner 1978).

Table 1. Forage use by domestic and wild ungulates in southeastern Oregon during 1975 (Kindschy et al. 1982).

Species	Percentage forage use
Domestic	
Cattle and horses	82.3
Feral horses	5.8
Sheep	0.7
Total	88.8
Wild	
Mule deer	10.1
Pronghorns	0.9
Rocky Mountain elk	0.1
Wild sheep	0.1
Total	11.2

interspecific relationships will be emphasized: compatibility; competition for forage, water and space; and hosts as reservoirs for diseases and parasites. Each of these factors will be analyzed for cattle, domestic sheep and horses.

Some interspecific factors affecting pronghorns are related to two or more classes of livestock, therefore, these will be discussed first. When pronghorn does give birth, they seek isolation from other pronghorns, other large animals or any major disturbance. In some regions, parturient does give birth year after year in traditional fawning areas that are crucial habitats for management objectives. Livestock have created various problems on these fawning areas: Barrett (1978) observed fawns trampled by cattle; Einarsen (1948) noted domestic sheep, sheepherders and dog disturbances; and McNay and O'Gara (1982) reported displacement of does by cattle in Nevada. The Nevada study was a two-year investigation comparing years with and without cattle on a fawning area. Does used traditional fawning areas when cattle were not present, but moved to adjacent sites when cattle were allowed on fawning areas. Such displacement, or competition for space, resulted in does moving to sites with less desirable vegetative height and made fawns more vulnerable to predation. Management recommendations to alleviate such multiple use problems include: delay turn-out of livestock until after the pronghorn's parturition period (mid-May to early July in sagebrush-grasslands), or the herding of stock concentrations (especially sheep flocks) from traditional fawning areas.

Rangelands dually occupied by livestock and pronghorns can be altered rapidly by livestock (Autenrieth 1978, Kindschy et al. 1982). Heavy livestock grazing can change vegetative composition and availability (Wagner 1978, Wald and Alberswerth 1989). These changes can affect both the quality and quantity of preferred forage needed to sustain thrifty pronghorn populations (Ellis 1972, Howard et al. 1983). This also has been observed for areas in California, Nevada and Oregon where historic heavy livestock grazing of grasses and forbs has resulted in increased tall dense stands of shrubs. Historic pronghorn habitats have been converted into shrublands no longer occupied because forage was less preferred and vegetation structure no longer met the pronghorn's needs. The decrease of native grasses and forbs was reported to increase vulnerability of fawns to predation in Idaho (Autenrieth 1982). In another case on the grasslands of western Texas, heavy use of native vegetation by livestock (which received supplemental rations on rangelands during a drought) forced pronghorns to turn to poisonous plants, resulting in direct mortality and subsequent reproductive losses (Hailey 1979).

At times, pronghorns and livestock have a commensal relationship. Rangelands with an abundance of grasses can be heavily grazed by livestock causing increased production of forbs and shrubs. Then too, pronghorns consume many plants known to be noxious or poisonous to livestock such as larkspur (*Delphinium* sp.), death camas (*Zygademas spp.*) and halogeton (*Halogeton spp.*). Often, these plants are highly relished and readily consumed by pronghorns without harm.

Most predator control is for the benefit of livestock. For instance, about 250 times as much money was spent for the protection of livestock during FY1976 than was spent for the benefit of wildlife (Connolly 1978). Predator control programs for livestock sometimes provide benefits to pronghorns. Connolly lists numerous cases of predator control increasing pronghorn populations.

A negative factor for pronghorn-landowner relationships is the increased frequency of pronghorn depredations to alfalfa (*Medicago sativa*) fields. During the 1950s, pronghorns were a serious depredation problem in Montana (Cole 1956). Now, with pronghorn populations four times greater, the incidence of crop damage has likewise expanded. California is now trapping and translocating herds causing depredation problems—a management practice intensified due to complaints from alfalfa producers (Pysora 1987).

Cattle. Aggressive behavior between cattle and pronghorns appears to be minimal. Pyrah (1987) observed pronghorns avoiding pastures with cattle. This was especially true during summers when vegetation was desiccated and pronghorns moved to adjoining rangelands with less competition from stock. Roebuck (1982) studied pronghorn-cattle relationships for two years in the Texas Pandhandle and reported pronghorns did not avoid concurrent use with cattle.

Competition for forage does not appear to be a serious problem for rangelands in good condition (Yoakum 1975, Salwasser 1980). Cattle are primarily grazers of graminoids, whereas pronghorns prefer forbs and shrubs. In more than 150 food habit studies of pronghorns throughout their range, the year round consumption of grasses averaged less than 10 percent (Sundstrom et al. 1973). Working in Colorado, Hoover et al. (1959) reported all the pronghorns in Colorado would not eat as much grass as 200 head of cattle.

The comparison of dietary overlap in Table 2 revealed ratings less than 30 percent for 9 of 10 studies, denoting a low competition factor. These are generalized tabulations over many different communities, but they are consistent in depicting the low rate of forage competition. Competition exists on a seasonal basis for some forage classes, especially during winter and spring. On a yearlong basis, competition is relatively low because of the consumption of different forage classes by the two species.

Domestic sheep. Investigators are not all in agreement concerning compatibility of pronghorns and domestic sheep. Competition between sheep and pronghorns was

Table 2. Dietary overlap in forage classes between pronghorns and cattle, sheep, and horses.

Class of livestock	Reference	Location	Biome	Forage class dietary overlap: Grasses	Forbs	Shrubs	Total Diet
Cattle	Buechner 1950	Trans-Pecos, Tx.	Grassland	4.0	7.0	9.0	20.0
	Campbell 1970	Southwest, Mt.	Grassland	3.0	20.3	1.6	24.9
	Becker 1972	Winnett, Mt.	Shrub-steppe	3.0	13.0	0.0	16.0
	Taylor 1975	Rawlins, Wy.	Shrub-steppe	7.1	0.2	39.4	46.7
	Hanley 1980	Northeastern Ca. & northwestern Nv.	Shrub-steppe	4.1	3.4	3.7	11.2
	Smith & Beale 1980	Southwest Ut.	Shrub-steppe	0.0	0.0	27.0	27.0
	Beason et al. 1982	Roswell, N.M.	Grassland	4.0	15.2	1.3	20.5
	Roebuck 1982	Panhandle, Tx.	Grassland	2.5	19.0	8.5	30.0
	Bailey & Cooperrider 1982	Trickle Mountain, Co.	Shrub-steppe	3.5	5.0	14.0	22.5
	Hansen 1986	Sheldon National Wildlife Refuge, Nv.	Shrub-steppe	5.0	9.0	1.0	15.0
Horses	Meeker 1979	Sheldon National Wildlife Refuge, Nv.	Shrub-steppe	3.0	23.0	2.0	28.0
	Hanley 1980	Northeastern CA. & northwestern Nv.	Shrub-steppe	2.5	5.2	5.0	12.7
	Bailey & Cooperrider 1982	Trickle Mountain, Co.	Shrub-steppe	3.5	2.0	31.0	36.5
	Hansen 1986	Sheldon National Wildlife Refuge, Nv.	Shrub-steppe	5.0	6.0	0.0	11.0
Sheep	Buechner 1950	Trans-Pecos, Tx.	Grassland	4.0	19.0	10.0	33.0
	Severson 1966	Red Desert, Wy.	Shrub-steppe	3.2	2.6	28.4	34.2
	Campbell 1970	Southwest Mt.	Grassland	3.0	27.3	25.3	55.6
	Taylor 1975	Rawlins, Wy.	Shrub-steppe	7.1	1.2	39.9	48.2
	Smith & Beale 1980	Southwest Ut.	Shrub-steppe	0.0	0.0	46.0	46.0
	Beason et al. 1982	Roswell, N.M.	Grassland	4.0	50.2	6.0	60.2

probably first referred to in the literature by Taylor (1936), who stated pronghorns do not do will on rangelands with sheep. Einarsen (1948) found that pronghorns usually avoided sheep, but Gregg (1955) observed that pronghorns fed near isolated, small bands away from the herder and dogs. Buechner (1950) concluded no physiological incompatibility existed between the species, but recent studies in Montana indicate that pronghorns feed less among sheep than among cattle (Campbell 1970, Freeman 1971, Pyrah 1987). However, Severson (1966) studied pronghorn-sheep interactions in enclosed pastures on the Red Desert, Wyoming and found few problems of compatibility or competition. Severson observed no apparent stress on either as a result of the other's presence.

The severity of forage competition between pronghorns and sheep is enhanced because both readily consume forbs and shrubs. Sheep ingest more grasses when available, otherwise both species often consume many of the same species and quantities of forbs and shrubs yearlong. Another grazing problem is that sheep are generally herded and at times make heavy use of forage, whereas pronghorns are dainty eaters, constantly on the move while feeding. For the six major studies (Table 2) of dietary overlap, all show ratios from 33 to 60 percent, indicating medium to high competition.

Field studies in South Dakota have disclosed higher incidence of parasites affecting pronghorns on rangelands occupied with domestic sheep compared to rangelands of non-dual use (Bever 1957). Use of phenothiazine salt blocks on sheep rangelands, and abandonment of close sheep-herding practices apparently alleviated the pronghorn parasite problem.

The exchange of diseases is a concern because the spatial distribution of pronghorns and livestock overlap extensively. The concern is whether either animal is a reservoir for maladies that affect the health of the other. Brucellosis and anaplasmosis have been repeatedly checked and pronghorns are not a reservoir. The pronghorn, compared with other wild ungulates, is noteworthy for its low incidence of diseases and parasites. Bluetongue is probably the most serious disease of pronghorns, and cattle are the primary reservoirs for the disease because they often do not develop symptoms but are chronic carriers (Thorne et al. 1982). Leptospirosis causes some mortality in pronghorns, but they seem relatively resistant to infection and may act as carriers. Insufficient evidence exists to implicate either pronghorns or cattle as the primary reservoir of infection. The existence of an unidentified reservoir species cannot be ruled out.

Horses. Domestic and feral horses occupy rangelands with pronghorns. We know of only two research endeavors that document aggressive interactions between horses and pronghorns (Meeker 1979, Berger 1986). Meeker's was a study for two summers on the Sheldon National Wildlife Refuge in northwest Nevada. He observed that both species grazed and watered together, and pronghorns gave ground only when directly confronted by horses. No aggressive actions were noted by either species towards the other. A second research project was conducted in Nevada near Gerlach by Berger (1986). He recorded six observations where pronghorns were displaced by horses; however, he reported no serious problems of aggression.

Table 2 includes four studies of dietary overlap between horses and pronghorns. All reported low levels of competition, that is, less than 30 percent yearlong because horses consumed grasses, whereas pronghorns preferred forbs and shrubs. Meeker's (1979) study indicated some overlap for forbs, as horses readily utilized that forage class during summers.

Rangeland Improvements

Rangeland practices designed to improve conditions for livestock can be beneficial or detrimental to pronghorns depending on how they are implemented. A number of cases are on record regarding the relationships of pronghorns to projects initiated primarily for improving conditions for livestock (Yoakum 1980).

Vegetation manipulation. Artificial seedlings and brush control practices used to develop monoculture grasslands have limited values for pronghorns (Yoakum 1980), especially when accomplished in large blocks (5,00–15,000 acres—2,024–6,071 ha). The larger the project the further pronghorns have to travel to obtain preferred shrubs during plant succession of the project. Seeded grassland monocultures frequently have low densities and varieties of forbs. Many thousands of acres of sagebrush have been converted to monoculture grasslands with introduced perennial graminoids such as crested wheatgrass (*Agropyron cristatum*) (Johnson 1986). Pronghorns do not consume much grass, and when they do, they prefer softer textured bunchgrasses, such as Sandberg bluegrass (*Poa secunda*).

The results from more than 30 years of studies by Plummer et al. (1968) indicate dominant shrublands or pinyon-juniper communities can be successfully rehabilitated for livestock and wildlife. This requires control of the dominant plant species, followed by seeding to complex mixtures of at least six species each of grasses, forbs, and shrubs. If more species can be planted, a more favorable seeding for wildlife is produced because of diversity. Herein lies a major differentiating factor between livestock and wildlife management. Rangelands that are primarily grassland serve the needs of livestock well. Rangelands having a variety of species for all forage classes best serve pronghorns and other wildlife.

One rationalization often used for justifying single-species seedings is the cost of seed. A single-species seeding may cost one-quarter or less of a complex seeding; however, the lower cost cannot be justified for rehabilitating public lands since passage of the National Environmental Protection Act of 1969, the Federal Land Policy and Management Act of 1976, and the Surface Mining Act of 1977. These public laws make it clear that the public's lands are to be managed for their natural resources.

One method of evaluating treatment projects for livestock and wildlife is the monitoring of animal responses to the projects. One of the most extensive rangeland rehabilitation programs to date is the Vale Project for public lands under jurisdiction of the U.S. Bureau of Land Management (Heady and Bartholome 1977). Although designed for multiple-use, the 11-year large-scale program emphasized forage and water improvements to restore livestock carrying capacity. The 60 by 75 mile (96 by 120 km) area was 90 percent sagebrush-grasslands. Much of the area was producing less than 50 percent potential forage due to deterioration from past heavy livestock use. After congress appropriated approximately $10 million beginning in 1963, the following improvements were made: 506,000 acres (204,778 ha) of brush control, 26,700 acres (108,055 ha) of artificial seedings (both single and simple mixture), 2,000 miles (3,218 km) of wire fences, 600 water developments and 463 miles (745 km) of pipelines installed for better water distribution. Approximately 9 percent of the area was treated by brush control and artificial seedings.

Fifteen years later, transects were run to determine vegetative composition and height on treated and non-treated sites. The non-treated sites averaged 52 percent grasses, 3 percent forbs and 45 percent shrubs, with a mean height of 28 inches (71 cm). Plowed and seeded sites had 76, 11, and 13 percent, respectively of grasses, forbs and shrubs, with an average height of 18 inches (46 cm). Crested wheatgrass was the predominant species planted in all seedlings. Dryland alfalfa was included in 26 seedlings. Heady and Bartholome (1977) sampled treated areas and found most attempts at land rehabilitation succeeded. Projects reduced sagebrush density and structure while increasing grass and forb quality and quantity. Sagebrush was not eradicated, as it was abundant in surrounding communities and re-invaded to approximately 25 percent of ground cover.

An analysis of pronghorn numbers for the large-scale restoration project compared with similar surrounding lands receiving minor improvements was obtained from state wildlife agency aerial censuses. During the early years of the project (1962–64), the herd averaged 1,420 per year in the project area. Following implementation of the improvement practices (1972–74), the herd nearly doubled to 2,600. During the same period, herds on surrounding rangelands increased less than 30 percent.

Fences. Fences can be major obstacles restricting pronghorn mobility to procure food and water or escape from deep snow. Such obstacles can be disastrous for northern herds during seasonal movements from summer to winter rangelands (Spillett 1965, Sundstrom 1968). Similar movement problems in Texas were noted by Buechner (1950) and Hailey (1979). How livestock fences are constructed can have an impact on pronghorns and other wildlife. As early as the 1870s, Caton (1877) noted pronghorns characteristically go under barbed-wire fences rather than through or over.

Recommendations for wire fences that best allow pronghorns to negotiate are provided in a number of research projects and agency guidelines: Spillett 1965, Mapston and Zobell 1972, and U.S. Bureau of Land Management 1985). Figure 2 illustrates suggestions for wire fence specifications (Kindschy et al. 1982). Such fences allow animals to go under the bottom wire, which they customarily do. Many miles of "sheep tight" or woven wire fences have been constructed that became barriers to pronghorn mobility. The so-called "wolf-type" fence constructed with woven and barbed wire is restrictive to pronghorns (Yoakum 1980). The biological effects and legal implications of the "wolf-type" fence are well documented in the

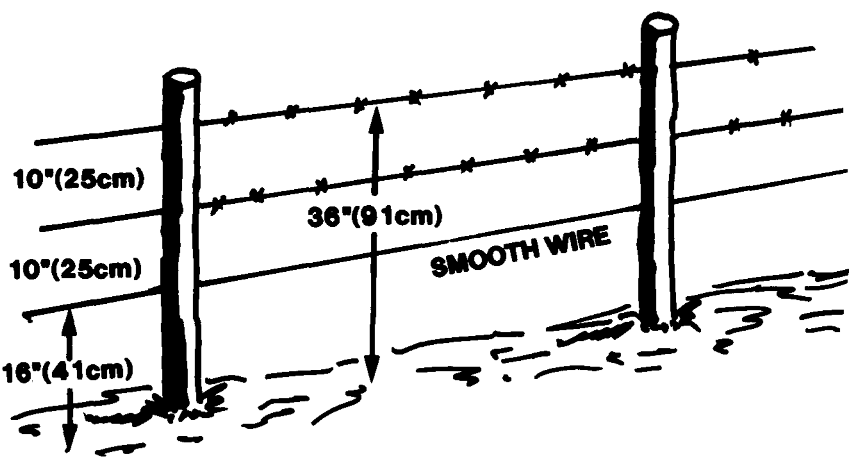

Figure 2. Suggested specifications for barbed wire fences constructed on rangelands dually occupied by pronghorns (Kindschy et al. 1982).

legal hearing held during April 1978 (Gist Ranch, New Mexico 6-78-1, August 21, 1978). The final conclusion was "wolf-type" fences were legally constructed on public lands prior to passage of the Federal Land Use and Management Act of 1976; however, this new Federal law mandated multiple-use on BLM administered rangelands and such fences now violate that mandate.

In some areas of the southwest, ranchers encircle water sources with fences to trap or redistribute livestock. Closing the gates restricts animals from the water and forces movement to other rangelands. The enclosures are often constructed of woven wire, six or more barbed wires, or snow-control fencing. Fenced water sources have detrimental effects on wild ungulates. The effects are most noticeable for young animals that are inexperienced in negotiating such facilities. The fencing of water holes violates the same basic mandate of rangelands multiple-use as "wolf-type" fences.

The feasibility of constructing special facilities that could allow pronghorn movement through livestock fences was investigated in Wyoming (Mapston and Zobell 1972). The result was a designed structure called an "antelope pass" allowing some movement by pronghorns; however, the authors were explicit in identifying limited mitigating values of these facilities.

Wildlife biologists working in Idaho adjusted wire fences to allow for seasonal movements of pronghorns when rangelands were not used by livestock (Anderson and Denton 1980). The height of the lower wire is increased from 18 to 38 inches (46 to 96 cm). This has special merit for areas experiencing snow depths of 12 inches (31 cm) or more, thereby restricting movement under the fence and at times resulting in entrapment.

Water developments. During a five-year study of pronghorns on sagebrush-grasslands in Wyoming, Sundstrom (1968) observed pronghorns using every type of water source available: springs, reservoirs, water catchments, streams, lakes and troughs filled by windmills. At time, pronghorns were seen using water developments with domestic livestock. Sundstrom noted that, when water exceeded a pH of 9.25, pronghorns appeared to seek other sources. He also found little or no pronghorn use of water developments containing total dissolved solids in excess of 4,000 ppm. Studies in western Utah (Beale and Smith 1970) suggested water developments may encourage distribution of pronghorns where natural water sources are limited, particularly during dry seasons or drought years. Examples of water developments constructed for livestock and pronghorns include the following.

Hundreds of small reservoirs have been constructed to trap and retain precipitation. Many of these have been built on public lands through cooperative funding by state and federal management agencies. Such developments are often natural in appearance and serve a variety of wild fauna. In Malheur County, Oregon, 1,037 reservoirs were completed for livestock and wildlife needs (Heady and Bartholome 1977).

Another water development highly used by pronghorns is the dugout or trench reservoir, especially during late summer when vegetation becomes desiccated, and the animals physiological requirements for water increase. Dugouts are most commonly used in areas of comparatively flat but well-drained terrain. A natural pothole or dry lake bed is often a good location for a dugout.

Wildlife on western rangelands probably use springs and seeps more than any other source for drinking water. Sometimes these sources can be developed to improve water availability; however, the practice can be tricky in that it is also possible to lose the water source during development. No two springs are alike; consequently, several different planning techniques can be applied. Fencing the water source and collection basin from human or cattle use is a good conservation practice.

Rangeland managers may construct water developments such as tanks, troughs, or wells for multiple-use benefits; e.g., for livestock, campgrounds, and fire suppression. Often, a slight modification or addition to such developments can provide water for wildlife. Managers desiring additional information or specifications, plans and construction details for water improvements will find sources in Valentine (1971) and Yoakum (1980).

Discussion and Management Recommendations

Increasing human populations result in an ever increasing demand for land. Improved techniques are needed to produce sustained benefits. For western rangelands, this means practices to produce optimum sustained yields of livestock and wildlife. One combination of factors favorable to this concept is the production of pronghorns with livestock. Experiences during the past 50 years tell us that we can maintain a sustained yield of both for aesthetic and consumptive uses. This requires coordinated management practices for both classes of animals. Standards for livestock husbandry and pronghorn enhancement have been developed, but not well coordinated. Despite this, production of both has increased during the last half century. Possibly, through better understanding, this trend will continue. We have worked with this challenge and suggest the following:

1. Rangelands can produce concurrent high production of livestock and pronghorns. The key is maintaining the rangeland in quality condition. Both livestock and pronghorn thrive in subclimax ecological condition, but production decreases on poor condition rangelands.
2. Management plans need to incorporate the requirements of both animals simultaneously. Past practices may not be appropriate, for they have not always recognized both animals. This requires that managers must be knowledgeable of the requirements for both and implement practices to meet both animals requirements.
3. We cannot stress too strongly that, if managers maintain or improve forage, waters and soils, animals have a good chance to maintain healthy numbers and condition. Time is required to know, understand and implement techniques to maintain rangeland conditions. Healthy rangeland produces healthy animal populations.
4. Based upon our experience to date, the following guidelines will help maintain dual use by pronghorns and livestock on rangelands.
   a. Both animals exhibit tolerance and compatibility when they run together in reasonable numbers on rangelands in fair to good condition. Aggressive actions are not a major problem, but pronghorns need isolation during the parturition period.
   b. Natural vegetation should be maintained to provide an abundance and variety of forage classes. Most livestock graze grasses; pronghorns primarily consume forbs and shrubs. Rangeland producing a mixture of grasses, forbs and shrubs will best serve livestock and wildlife. The cardinal rule is to maintain

existing rangelands with natural vegetation. When deteriorated areas require rehabilitation, practices that restore vegetation to natural diversity are more desirable than practices that bring about monocultures or unnatural conditions.

c. Practices that increase drinking water catchment and retention are highly beneficial to both animals. Such waters are especially valuable if available every 2–3 miles (3.2–4.8 km). Such water improvements can be made in any number of ways; however, those that simulate natural drinking waters are most favorable and cause few entrapment problems.

d. Both pronghorns and livestock experience problems with predation, diseases and parasites. Consequently, management practices need to recognize how these factors affect the animals and coordinate control techniques beneficial to both.

In summary, the last 50 years have proven pronghorns and livestock can live together successfully on rangelands in good condition. Some, but relatively few, problems of compatibility or competition exist for forage, water or space. It can be said that pronghorns and livestock are the epitome of multiple-use in modern times on western rangelands.

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Experimental Stewardship Program: An Underpublicized Success Story

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The Experimental Stewardship Program (ESP) was a "buzzword" within rangeland management circles during early 1980s. It seemed to offer lots of answers for improving rangeland management. So what happened to ESP?

The Experimental Stewardship Program is not only very much alive within the three nationally designated rangeland areas, but it has proven to be an extremely successful program where properly applied. To help you understand how really successful it has been, here are some basic background and organizational processes that have made success possible, plus some examples of success within our program.

Three nationally designated areas were established following passage of the Public Rangelands Improvement Act of 1978. This Act directed the secretaries of the Interior and Agriculture to establish an experimental program to provide incentives or rewards for *livestock-grazing permittees and leasees* to improve the condition of public rangelands. The three nationally designated areas are the Challis near Challis, Idaho, the Modoc-Washoe in northwestern Nevada and northeastern California near Alturas, California, and the East Pioneer near Dillon, Montana.

All three areas had significant rangeland problems before ESP. Resource conflicts existed, and vegetative condition and trend needed to be improved. Relations between ranchers, agencies and other user interests were at or fast approaching the point where no one would even discuss the problems. In many instances, costly legal action appeared to be the most likely alternative for all interests involved.

Enter ESP. The program essentially forced the different interests to sit down and discuss just what they really wanted for the rangeland areas involved. All three areas developed a "steering group" to identify common objectives, direct the program and make needed decisions. Organization within this steering group is key to making your program work. The number of representatives on the steering groups varied from 13 on the East Pioneer to 21 on the Modoc-Washoe.

Three critical considerations appear necessary for structuring an effective steering group:

1. Be certain that all major interests concerned about management of the area in question are represented. Be realistic; you can have only so many representatives in any workable group, so one individual may have to represent more than one group or agency.
2. Representatives must hold sufficient status within their agency or organization

to truly represent that interest and be able to make decisions for that interest.

3. Representatives must be willing to negotiate to achieve desired objectives for the involved area.

Once the steering group has been identified, the members need to establish common objectives. Hopefully, you will find, as those in the three national areas did, that all responsible interests are really after the same thing—a healthy, vigorous rangeland capable of supporting multiple resource values and uses.

Once the steering group has established basic objectives for an area, alternatives must be developed to achieve the objectives.

A technical action group—composed of resource specialists and involved landowners, permittees and other special interest representatives—represents the next key group. It is assigned the task of reviewing the area's resource capabilities. This group identifies alternatives, including the preferred alternative, for achieving objectives identified by the steering group. These alternatives are presented to the steering group for a decision on how to proceed. Differences are worked out through the negotiation process, with an objective of reaching consensus on the final alternative. Once the decision is made, it becomes a group decision and all interests are committed to making it successful. As indicated, this process is working very well within the three national ESP areas. The process has been applied to other resource problems with equal success. Participants believe that this process can be applied successfully to essentially any problem involving resource conflicts.

The initial legislation stressed the need to identify incentives and rewards necessary to get permittees to improve range condition. All groups found out that the real incentive and reward necessary to get all participants to work together towards improved range condition were simply to improve communications and work in a coordinated, cooperative process where all interests could be heard.

Unlike many special programs, significant funds were not diverted in an effort to force the program to work. Congress did not appropriate additional funding for the program. In East Pioneer, we made a point of ''making do'' with available funding. Equally important is that all three areas made no attempt to restrict incentives and rewards to grazing permittees, but recognized the valid interest held in rangelands by all user interests. Specific effort is made to keep everyone involved. Most important of all is that the basic rangeland resources have benefitted, as have the user interests who have worked *together* to make it happen.

Allotment Management Planning was a major job in all three areas. Involving all concerned interests helped to expand other resource considerations and gain needed commitment to make these plans really meaningful. The following examples are all from our East Pioneer area, but similar success stories could be told by any representative.

1. Critical elk winter range was identified on the Vipond Allotment, where livestock water development was planned. The water was not developed to help reserve involved forage for wintering elk.
2. Lack of water seriously restricted livestock distribution on the Dry Hollow pasture on the Vipond Allotment. We needed to raise water over 900 vertical feet. A waterwheel was installed to provide power with minimum maintenance. Water is held in a storage tank and distributed as needed to water troughs on lands administered by the Forest Service, Bureau of Land Management (BLM) and Department of State lands.

3. Noxious weed invasion became an important issue. We implemented a coordinated program designed to gain control of noxious weeds on all ownership within the East Pioneer area. This program has proven very successful and is being used as a model for expanding this type of a program throughout Montana and other states.
4. The BLM administers a significant riverfront area along the Big Hole River, a nationally important trout fishing stream. It needed to develop a recreation plan to guide management along this river corridor, but had encountered opposition to initial efforts. BLM requested assistance from our group and, by using our approach, completed the plan in less than one year without further opposition.
5. Travel management is a major program for maintaining wildlife security and preventing soil erosion in our area. We have helped the BLM, Forest Service, and state fish and game revise the Interagency Travel Plan for southwest Montana.
6. We have just initiated an experimental program to translocate beaver back into streams where they have been trapped out in the past. The objective of this program is to improve riparian values and increase water storage in the headwaters so we get more late-season water flow.

These are just a few examples of significant achievements within the East Pioneer ESP. Similar success stories can be told by participants in the other ESP areas.

Participants in all three areas have been very pleased with progress we have made. Please note that this does not just include the livestock permittees and leasees, as identified in the original legislation, but the agency, wildlife, environmental and other interests that we have involved directly in management decisions on the ground!

In conclusion, let us add that representatives from all three areas have expressed interest in discussing their programs with anyone who might be interested. We are equally interested in helping to expand the program to help resolve problems in other areas. Please let us know if you have a problem we might help you solve.

Special Session 10. *Compensatory Responses in Wildlife Populations*

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Compensation in Furbearer Populations: Current Data Compared with a Review of Concepts

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Introduction

The term compensation has been applied to density-dependent relationships among reproduction, mortality and dispersal in vertebrate populations. The basic ecological concepts have important implications for the management of populations, particularly of exploited species. Earlier in the history of wildlife management, research into these population mechanisms was a common interet of ecologists and applied wildlife biologists, but today these groups are more distant in their research interests (Wagner 1989). Changes in the sociopolitical climate constantly demand that wildlife researchers clarify the population mechanisms that form the basis for harvest management. Harvest of furbearers by trapping is one of the most controversial issues facing the wildlife profession (Novak 1987).

I felt it would be useful to examine the hypotheses related to compensation in furbearer populations because studies of furbearers were historically important in the development of exploitation theory. I will restrict this discussion to medium-sized mammals harvested for both recreational and commercial purposes, although the principles may apply to marine furbearers and larger mammals. Furbearers are ideally suited to testing exploitation theory because they are nonmigratory, they represent a variety of taxonomic groups with differing life histories (Dixon and Swift 1981), large samples are easily captured and marked, population densities vary substantially and harvest effort varies in response to trapping conditions (Clark 1987). My objectives are: (1) to review briefly the origin of the concept of compensation and its relation to furbearer management and (2) to compare data from recent studies of muskrats (*Ondatra zibethicus*) and raccoons (*Procyon lotor*) with testable predictions derived from the concepts.

Compensation and Compensatory Mortality

The concept of compensation as it is interpreted in game management was derived by Errington (1946, 1956, 1963) from his observations of bobwhites (*Colinus virginianus*) and muskrats. He was interested in interactions of all factors affecting the dynamics of populations, including reproduction, mortality, and dispersal. During his long-term observations of the annual fluctuation in abundance of these species, Errington was impressed by the relative constancy of late-winter population levels. He related this to carrying capacity of the habitat, social intolerance and the compensatory interaction of mortality factors. Specifically regarding his observations of predation by mink on muskrats, Errington (1946) wrote: "We may see that a great deal of predation is without depressive influence. In the sense that victims of one agency miss becoming victims of another, many types of loss—including loss from predation—are at least partly intercompensatory in net population effect." Errington's intuitive ideas on the annual fluctuation in numbers are often represented schematically (e.g., Bailey 1982) as in Figure 1. His ideas contributed to the broader questions of density dependence and population regulation that were widely debated by population ecologists (Keith 1974, Lidicker 1978).

The most quantitative evidence for density dependence presented by Errington (1954, 1963) showed that spring to fall increase of muskrats (N_f - N_s, net recruitment) was inversely related to prebreeding population in spring (N_s, Smith et al. 1981). The relationship has often been referred to as the principle of inversity (Errington

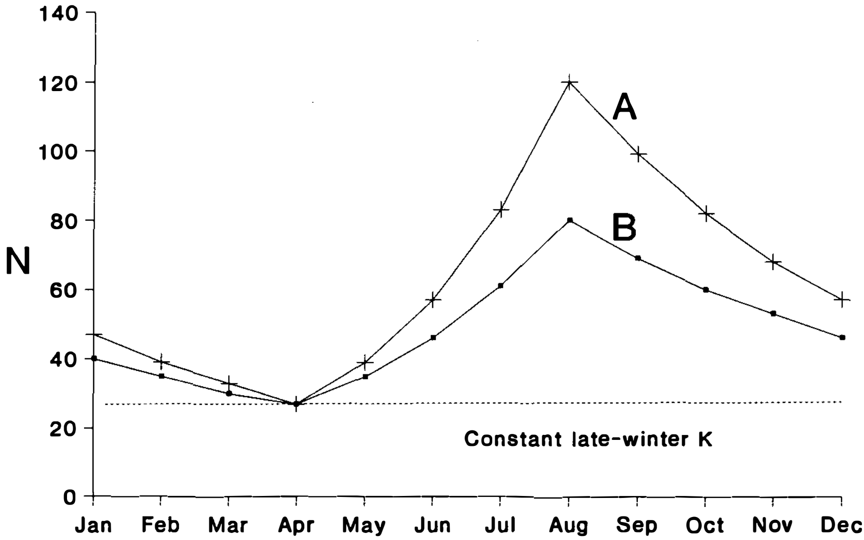

Figure 1. Annual fluctuation in the size of a hypothetical furbearer population. Survival from August to April is 0.23 in case A and 0.34 in case B.

1954, Allen 1962), and appears widely in ecology and wildlife management texts (e.g., Bailey 1982, Krebs 1985). The principle has been supported by data from a variety of species, including furbearers (Sadleir 1969, Knowlton 1972, Fowler 1981, Morris 1989). The presumed mechanism underlying reduced reproduction is a "deterioration of living conditions" (Allen 1962:34), resulting in reduced body size or condition. In mammals, body size has been shown to be related to density, juvenile growth, time to maturity, litter size and survival (Sauer and Slade 1987). Curiously, Errington only partly recognized the contradiction in the observation of constant prebreeding population size and density-dependent recruitment, which requires that population size vary.

Although Errington's conceptual framework has been criticized from several viewpoints (Huffaker 1970, Keith 1974, Romesburg 1981, Taylor 1984), it still forms the basis for management of most small game and furbearer species. Furthermore, these concepts have been interpreted and extended to predict the effects of harvest on waterfowl. Anderson and Burnham (1976) explored some of these relationships in mallard (*Anas platyrynchos*) populations. They focused the discussion on the interaction among mortality factors separately from the issues of density-dependent response in reporduction (Nichols et al. 1984). Anderson and Burnham (1976) formulated two hypotheses representing the extremes of the relationship between harvest mortality and total annual survival, the completely compensatory and the additive hypotheses. Further, they emphasized the importance of understanding relationships among survival rates, rather than observing population levels from year to year. They brought the hypotheses closer to the realm of statistical theory of competing risks. Nichols et al. (1984) clarified the hypotheses and reviewed the evidence from studies of waterfowl.

Predictions from the Conceptual Framework

A number of predictions can be derived from the original conceptual framework and its extensions to the compensatory relationships among rates. Although the principle of inversity is widely held, there are a number of problems with the relationship. These have been recognized to varying degrees in more recent research. Most evidence is correlative rather than based on independent measurements of reproductive parameters in manipulated populations. The measurement of recruitment confounds changes in reproductive output with changes in early survival. Errington (1954) examined per capita rates of reproduction, like average litter size and pregnancy rate, in relation to population size, but failed to draw any strong conclusions except regarding net recruitment. Also, there is often a sampling correlation between recruitment and N_s, a problem that has attracted much attention in the literature (Eberhardt 1970). Furthermore, the estimates of population size or density were, and still are, often based on poor statistical methodology (Pollock et al. 1990). Reading Errington's (1946:93) accounts of procedures for estimating the numbers of muskrats emphasizes how far we have progressed in estimating the pertinent population parameters. Despite the recognition of the sampling problems, few attempts have been made to design studies that use rigorous estimation of reproduction and population size, avoid confounding reproduction and early survival, and minimize sampling correlation, thus providing conclusive evidence for inversity.

A prediction about the relationship between survival and density can also be derived from the conceptual framework. Errington observed variations in peak numbers of muskrats (Figure 1, e.g., curves A and B), which he attributed to variation in environmental conditions, especially droughts and disease. Because of this variation and the underlying assumption of constant carrying capacity, we are led to predict that overwinter survival will be inversely density dependent. Although this prediction was not precisely stated by Errington it is clear that he recognized it. Again appropriate statistical design is necessary to reasonably test the prediction.

Nichols et al. (1984:541) summarized testable predictions about the relationships between harvest and nonharvest mortality, based on the hypotheses of Anderson and Burnham (1976), and suggested that under the compensatory mortality hypothesis, annual survival should not be affected if, for example, the harvest rate was increased. Under the additive hypothesis, annual survival would be reduced. A second prediction is that if harvest rate is increased, there should be a decrease in nonharvest mortality after the season, assuming the intercompensatory nature of the rates. If there is no change in nonharvest mortality following a season when harvest is increased, the additive hypothesis is supported.

For the nearly the last decade I have been directing studies of furbearers that attempt to confirm or refute some of these predictions. I want to compare data from studies of muskrats with the predictions derived from Errington's concepts of compensation, especially inversity in reproductive rates, and density-dependent overwinter survival. Then I will use data from long-term studies of both muskrats and raccoons to reflect on relationships between harvest and nonharvest mortality.

Comparison with Current Evidence

Studies of Muskrats

The evidence is derived from long-term studies on the Mississippi River (Clay and Clark 1985, Clark 1987) and ongoing studies of muskrats at Delta Marsh, Manitoba in cooperation with the Marsh Ecology Research Program (MERP, Murkin 1984, Kroeker 1988). In both studies we used intensive trapping and marking to estimate population size and survival. The MERP studies are unique in that the marsh habitat was divided into cells, and water levels were replicated so that we could examine reponses in vegetation and muskrat populations. I expected differential response of muskrats to water levels and vegetation, and therefore hoped this design would be an indirect way to manipulate muskrat density. I estimated population size in May ($\hat{N}_s$) and September $\hat{N}_f$) using the methods of Otis et al. (1978) and estimated overwinter survival (ϕ_i) and rates of increase ($\hat{B}_i/\hat{N}_i$) using Jolly-Seber methods (Arnason and Schwarz 1986, Kroeker 1988). By using one method to estimate population size and another to estimate rates of increase and survival, I reduced the difficulties of sampling correlation. Clay and Clark (1985) used similar approaches on the Mississippi River, and Clark (1987) used banding analyses (Brownie et al. 1985) to compare directly models with the underlying assumptions of compensatory and additive mortality (Nichols et al. 1984).

When the MERP cells were flooded, muskrats rapidly invaded and reached densities greater than 30/ha after the second growing season. Although the population levels did not respond consistently to the flooding treatments (Kroeker 1988), per capita rates of increase ($\hat{B}_i/\hat{N}_i$) were inversely related to the $\ln(\hat{N}_s)$, very similar to the relationship Errington (1954, 1963) found (Figure 2, r = − 0.963, P = 0.001).

I also observed density-dependent effects on condition and growth. Body condition index (BCI) was density-dependent, and the reduction was remarkably similar among birth-year (BY) and after-birth-year (ABY) muskrats (BY: r = −0.507, P = 0.007, ABY: r = −0.518, P = 0.006, Kroeker 1988:25). Furthermore, weight gain during winter was inversely related to fall population size (Kroeker 1988). These observations are consistent with the hypothesis that declines in reproduction and survival are related to deterioration of available resources.

Estimates of overwinter survival (ϕ_i) were also inversely related to population size (Figure 3, r = −0.637, P = 0.002). Reductions in survival were variable and occurred over the full range of observed densities.

Manipulating harvest rate was not a part of the MERP design, but I have been able to look at the variation in survival using data from studies on the Mississippi River (Clay and Clark 1985, Clark 1987). I showed that annual survival of muskrats was related to age; for BY animals annual $\hat{S}$ = 0.16, whereas for ABY animals $\hat{S}$ = 0.06 (Clark 1987). This age dependence suggests that the inverse relationship of survival to population size (Figure 3) may differ among ages. Data from the Mississippi River studies suggest a mechanism for this age- and density-dependent response. Birth to fall survival of BY animals was greates in seasons following greatest harvest, and thus reduction in overwinter populations (Clark 1987).

When examining the variation in annual survival in response to widely-varying harvest rate, I was unable to reject a model with the underlying assumption of compensation (Clark 1987). Clark (1987) pointed out that this may have been the result of lack of statistical power, as McCullough (1990) has amplified. Annual survival of muskrats is low, so there is great potential for compensation (Nichols et al. 1984), and the Mississippi River studies confirm this prediction. For example, I

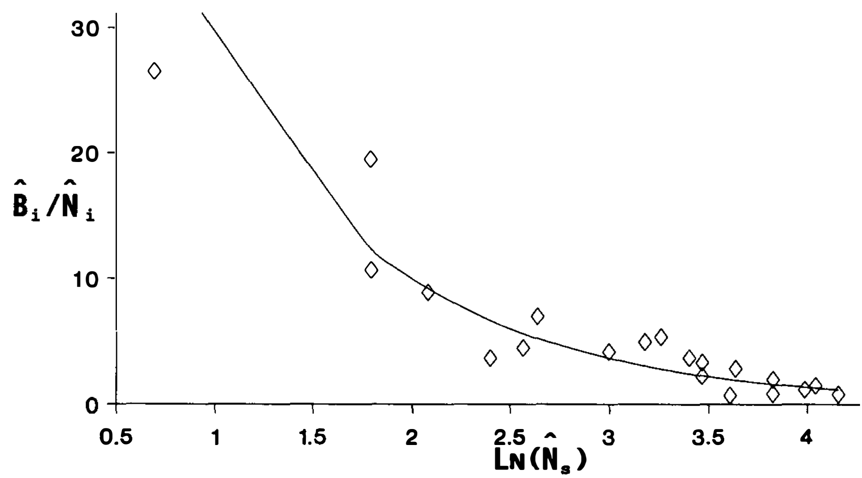

Figure 2. Per capita spring-fall rate of increase of muskrats as a function of spring population size at Delta Manitoba, 1986–1987.

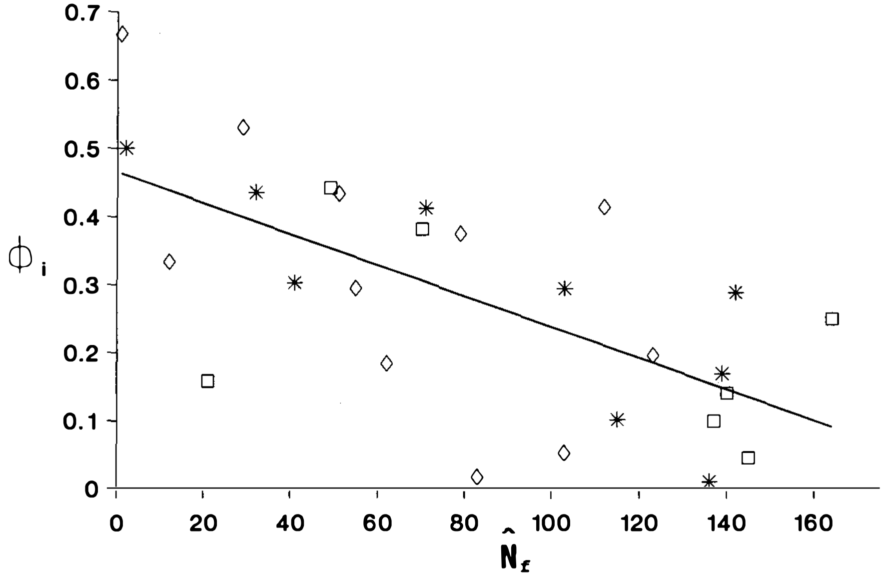

Figure 3. Overwinter survival of muskrats as a function of fall population size at Delta Manitoba, 1985–1988.

observed variation in nonharvest survival ($CV(\hat{S}_{nh})$ = 0.125) that was less than 50 percent of variation in harvest rate ($CV(\hat{H})$ = 0.284, Clark 1987:269).

Studies of Raccoons

Although these studies of muskrats provided some new insights into density-dependent relationships in populations, they are limited by the lack of direct manipulation of harvest rate and because cause-specific rates cannot be estimated for portions of the year (Nichols et al. 1984, Clark 1987). In 1983, Clark et al. (1989) began long-term studies of raccoons, in which we attempted to manipulate harvest rate from a mean rate of 20 percent of the October population level, observed during the first three years of the study, to the estimated 40 percent maximum sustainable rate. If the increased harvest is additive mortality, I predicted: (1) decreased survival during the harvest season, (2) no change in survival in the winter-spring following increased harvest and (3) decreased annual survival. If compensation among rates holds true, I expected: (1) no change in survival during harvest, subsequent season, or annually, or (2) if survival declines during harvest, that survival would increase in a compensatory fashion during the winter-spring following increased exploitation. I estimated cause-specific survival rates among BY and ABY raccoons using methods of Heisey and Fuller (1984, Clark et al. 1989) and by Kaplan-Meier estimators modified for left-truncated data (Pollock et al. 1989, Habrouck and Clark unpublished data).

Although I have meaured reproductive responses in raccoons, I will not report them in detail herein. It is sufficient to say that reproduction in raccoons is related to age and condition (weight), but is not conclusively density dependent (Fritzell et al. 1985, Clark et al. 1989). This aspect of population response to exploitation awaits further analysis.

Over 75 percent of all mortality among raccoon was due to harvest (Clark et al. 1989). Increasing harvest appears additive among BY raccoons because annual survival after we increased the harvest rate ($\hat{S} = 0.26 \pm 0.05$) was significantly less than during the first years of the study ($\hat{S} = 0.47 \pm 0.06$, $X^2 = 8.74$, df = 1, $P = 0.003$, Figure 4). The lower annual rate was caused by significantly lower survival during the harvest season in years of high exploitation ($X^2 = 14.53$, df = 1, $P = 0.001$). Based on the predictions of Clark (1987), I expected winter-spring survival of BY animals to increase after we increased harvest, similar to the segment marked C in Figure 4. However, there was no predictable increase in survival in the winter-spring period following each harvest season ($X^2 = 5.99$, df = 5, $P = 0.307$, Figure 4, Hasbrouck and Clark unpublished data). Perhaps because winter-spring mortality of raccoons in Iowa is so low, there is little potential for compensation.

Among ABY animals, I found no significant differences in harvest-season ($X^2 = 0.03$, df = 1, $P = 0.87$) or winter-spring survival ($X^2 = 4.84$, df = 5, $P = 0.44$), implying that increased exploitation is compensatory. I found that the annual survival rate was not significantly lower ($X^2 = 1.98$, df = 1, $P = 0.16$), despite an outbreak of canine distemper before the harvest season in 1988 (Hasbrouck and Clark unpublished data). Predominant causes of mortality are temporally separated—harvest in fall, vehicle collisions in spring (Clark et al. 1989, Harbrouck and Clark: unpublished data). It is difficult to imagine how losses from vehicle colisions could be density dependent in the same way subsequent losses to predators or disease might be in another population.

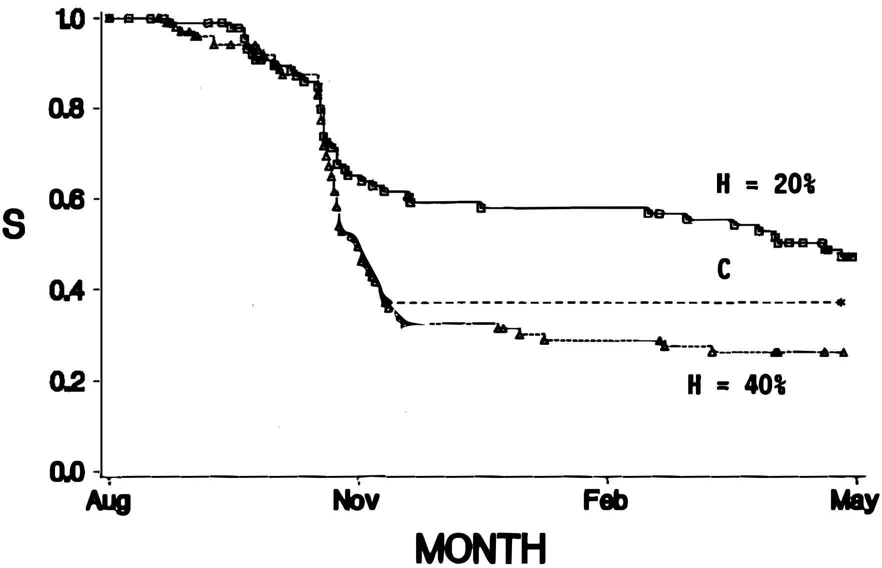

Figure 4. Survivorship of birth-year raccoons in Iowa under harvest regimes averaging 20 percent and approaching 40 percent of the fall population size. Segment C indicates the pattern expected if mortality was compensatory after increased harvest rates.

Discussion

The results I have presented on muskrats are very similar to the ideas described by Errington (1963). The principle of inversity in reproduction in muskrats is further supported by the addition of results on density-dependent somatic growth. The MERP studies also confirm density-dependent overwinter mortality.

In raccoons, a species longer lived than muskrats, interactions among mortality rates appeared compensatory among ABY animals, especially during the harvest season. Perhaps there are differences in behavior or habitat selection which contribute survival value, although Glueck et al. (1988) were unable to detect it. I note that the contrast of additive rates among BY raccoons and compensatory rates among ABY raccoons is contrary to what one would predict based *a priori* knowledge of annual survival. Interaction between mortality rates among BY animals has potential to be more compensatory because their average survival is lower.

Even among muskrats, where annual turnover is so great, there is support for age-specific density dependence. Using age-specific Jolly-Seber models (Pollock et al. 1990), I hope to test the prediction that the changes in overwinter survival as a function of population size are not the same for BY and ABY animals.

The raccoon studies in Iowa emphasize that harvest may be the predominant source of mortality in exploited furbearer populations. Further, sources of mortality, other than harvest are separated temporally, with very little nonharvest mortality occurring during the short effective harvest season. This is an extremely important observation because it suggest that compensatory responses in nonharvest survival to variation in harvest rates will be sequential rather than simultaneous as in competing risks (sensu Ricker 1975, Nichols et al. 1984). And because of the sequential response, there will be time-lag effects which will further influence the population dynamics. Telemetry techniques now enable us to estimate survival for seasonal intervals accurately and to study the sequential nature of compensation. There is a need for a more complete theoretical framework that integrates our understanding of temporally separated mortality with ideas derived from competing risks.

Only recently have we had the statistical procedures and been able to collect sufficient data to base conclusions about density dependence and compensation on precise and independent estimates of N and S. We will be able to make much stronger inferences about population mechanisms by estimation of rates, so we can separate the birth and death processes, cause-specific mortality and seasons of the year. Conclusions based on observations of constant population size, as Errington inferred, will necessarily be weak.

Although more clearly attempting to manipulate density and harvest compared with earlier observational studies, I encourage caution about interpretation of our studies of muskrat and raccoons. They are not unambiguous tests in the sense of Romesburg (1981) because of lack of spatial and temporal replication. It is expensive and time consuming to do the necessary experiments (Nichols et al. 1984) on a large scale. I continue to believe that furbearers are good candidates for experimentation.

My discussion relates to tests of specific hypotheses about interactions of rates in populations. Although predictions about density dependence in harvested furbearer populations have been extant since the time of Errington, game biologists are just now collecting the data to conclusively test hypothesized relationships. Nothing I have said implies that these furbearers, or others with similar life-history characteristics, cannot sustain regulated harvest. In populations with very great annual turnover like muskrats, additive and compensatory differences may be of little practical significance, resulting in no difference in management strategy. And additive mortality does not necessarily imply that a population is not maintaining at least constant density. For example, in the raccoon populations in Iowa we have high densities which exist in secure habitat, and the interaction of reproductive and mortality rates including harvest, yields positive net rates of growth. Furthermore, observed harvest by trappers and hunters is far below the theoretical maximum harvest rate (Clark et al. 1989). Nonetheless, further understanding of population relationships should be pursued so we might continue to base management on sensible inferences.

Acknowledgments

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A Review of the Evidence for the Effects of Hunting on American Black Duck Populations

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Introduction

The decline of the continental American black duck (*Anas rubripes*) population has concerned natural resource managers for the last four decades. This concern resulted in the formation of the Atlantic flyway Black Duck Committee in the late 1940s, which became the core of the nascent Atlantic Waterfowl Council (Barske 1968:1, Spencer 1975). Populations of black ducks probably were higher during this period than they have ever been since; inconsistencies in survey methods make direct comparisons with present population estimates difficult, but winter surveys in the early 1950s recorded counts of 500,000–700,000 black ducks (Martinson et al. 1968). By 1968, the population status of black ducks apparently had deteriorated significantly, with winter counts declining to fewer than 500,000 ducks, prompting the formation of a new "Black Duck Committee" and the sponsoring of a symposium to discuss black duck research and management issues (Barske 1968). Through this period, consideration was given to the possibility that hunting mortality was limiting black duck populations (Addy 1968:4, Martinson et al. 1968), although various efforts to moderate hunter take had no apparent effect on the population (Wilder 1968:168). Nonetheless, a major recommendation of the Black Duck Symposium was further restrictions in black duck harvest to allow recovery of breeding populations (Barske 1968:188).

Black duck populations continued to decline throughout the 1970s and into the 1980s at an average rate of about 1.5 percent per year (Rogers and Patterson 1984), although the exact rate of decline has been disputed, largely because of uncertainties in the winter surveys of the early 1950s. The issue of hunting as a limiting factor returned to the forefront by the late 1970s, culminating in a lawsuit filed by the Humane Society of the United States (HSUS) in an attempt to prevent the U.S. Fish and Wildlife Service (FWS) from opening black duck hunting seasons in the U.S. (Feierabend 1984, Rogers and Patterson 1984). The judge ruled against HSUS, in particular denying the contention that the Migratory Bird Treaty Act requires a presumption against hunting when a population is declining (Feierabend 1984). Shortly after the resolution of this case, J.W. Grandy, a witness for HSUS, published a treatise in which he reviewed FWS management of black ducks and castigated the

Service's "failure to take effective regulatory action to stop the decline," which he attributed primarily to hunting mortality (Grandy 1983).

Recent efforts to reduce further the kill of black ducks in the U.S. and Canada, in hopes of arresting or reversing the decline of continental populations, have not resulted in clear-cut responses of the continental black duck population, although analyses of the data from these efforts are currently underway (FWS Office of Migratory Bird Management unpublished data). We are not surprised, because the causes of the black duck decline are probably multiple and complex, and likely include factors such as habitat destruction and hybridization with mallards (*Anas platyrhynchos*) (Ankney et al. 1987, 1989, Conroy et al. 1989a). The present situation leaves managers in Canada and the United States in a dilemma. On the one hand they are vulnerable to criticism from those who contend that black duck seasons should be further restricted or even closed. At the same time, managers cannot demonstrate to the hunting public that such restrictions would "solve the black duck problem."

Herein we review the scientific evidence for the role of hunting in regulating populations, first for waterfowl in general and then specifically for black ducks. We use existing theory to elaborate an alternative model for the effects of hunting on waterfowl populations, which we think may be more biologically realistic than models presently in use. Finally, we elaborate on previously suggested management experiments that should help extricate managers from the dilemma in which they now find themselves.

The Hypotheses of Additive and Compensatory Mortality

Central to the discussion of the effects of hunting on black duck populations are the hypotheses of additive and compensatory mortality. We provide here a brief review of these hypotheses; readers are referred to Nichols et al. (1984) for a more complete discussion.

Prior to 1976, much of waterfowl harvest management was predicated on the assumption that harvest mortality of waterfowl was additive to other sources of mortality, resulting in corresponding changes in annual survivorship (Anderson and Burnham 1976, Nichols et al. 1984). The additive mortality hypothesis (AMH) states that nonhunting mortality rates (V) are independent of both population density and hunting kill rates (K), so that any increases in hunting kill rate result in total mortality in addition to that which would have occurred in the absence of hunting. Various analyses, including some performed on black duck data (Martinson et at. 1968, Geis et al. 1971) purported to show that hunting was additive for waterfowl, but Anderson and Burnham (1976) demonstrated that most of these were based on faulty statistical methods and hence invalid. The hypothetical relationship between K and total annual survival (S) under AMH is illustrated in Figure 1a.

The compensatory mortality hypothesis (CMH) proposes that below a "threshold" level ($K < c$), annual changes in K have no effect on S. The biological basis for this hypothesis is that density-dependent mortality occurs at some time of the year and "compensates" for changes in kill rates. Thus, if population density (N) increases (say, in winter) because of reductions in kill rates (e.g., a reduction in bag limits) risk of mortality from other factors (e.g., predation, disease, competition) will increase because some or all of these factors operate at greater rates at higher N.

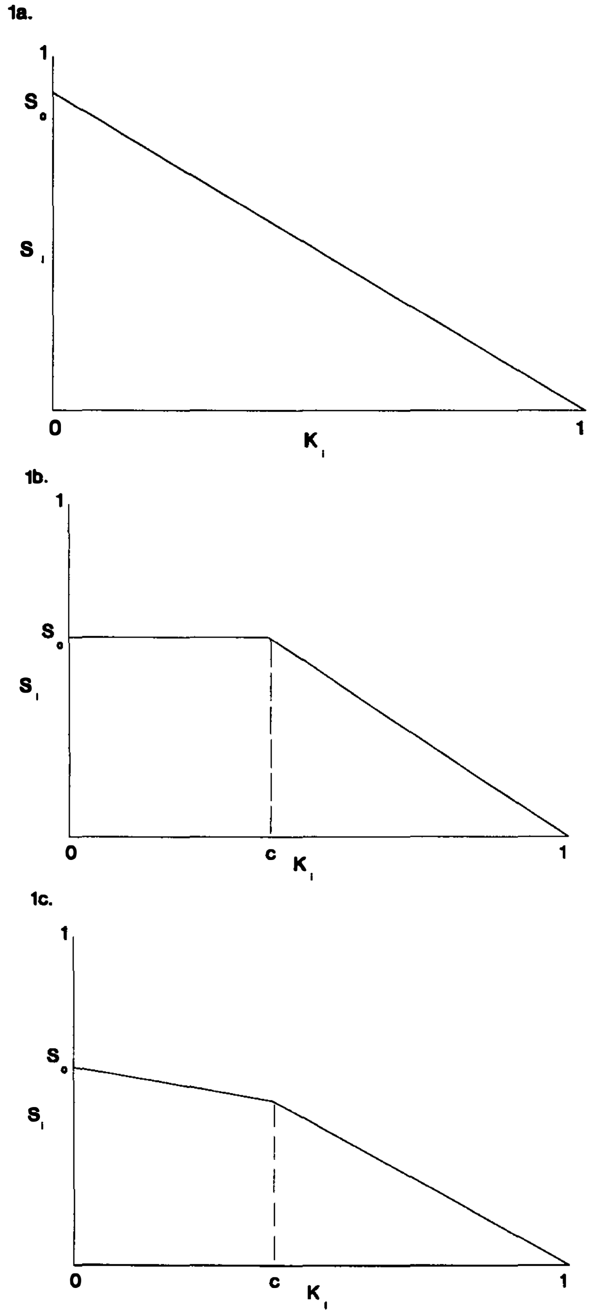

Figure 1. Additive (*a*), compensatory (*b*), and partially compensatory (*c*) mortality hypotheses. S_o = theoretical survival rate in the absence of hunting; c = threshold, beyond which K has additive effect on S.

Conversely, if K increases, risks associated with nonhunting mortality factors will decrease, because of lower population densities. If $K > c$, then hunting mortality will operate in an additive fashion, but below c, changes in K will have little or no effect on S. They hypothetical relationship between K and S under CMH is illustrated in Figure 1b. We note that these figures are somewhat idealized representations of the relationship between S and K under CMH and AMH, which for the purposes of this presentation are not substantially different from the exact relationships (K.P. Burnham pers. comm.).

The fundamentally different biological assumptions under AMH and CMH give rise to testable predictions (Nichols et al. 1984), summarized in Table 1. First, as we have already seen AMH predicts a negative relationship between S and K, while CMH predicts no relationship between S and K when $K < c$ (Table 1, Figure 1). Second, CMH predicts a negative relationship between K and nonhunting mortality rates after the hunting season, whereas AMH predicts that these two mortality rates are independent of each other. Finally, CMH predicts a positive relationship between V during some time of the year, and N; AMH predicts that V and N are independent of each other.

These three predictions are logically and mechanistically related and, in fact, Predictions 1 and 2 follow deductively from Prediction 3 (Table 1). In other words, density-dependent mortality is a necessary condition for CMH to be true, and if nonhunting mortality is compensatory to changes in hunting mortality, density-dependence must be the mechanism whereby that compensation occurs. We also note here, as did Nichols et al. (1984), that the mechanics of statistical hypothesis testing differ for these three predictions. For Prediction 1, CMH is the statistical null hypothesis, whereas for Predictions 2 and 3 AMH is the statistical null hypothesis. As we will see later, these distinctions become important as we consider the evidence in favor of each hypothesis and consider the risks of incorrectly choosing which hypothesis best represents the role of hunting in black duck populations.

Table 1. Predictions under the additive mortality (AMH), compensatory mortality (CMH), and partially compensatory mortality (PCH) hypotheses.

	Predictions		
Relationship between	AMH[a]	CMH[a]	PCH[b]
1. Annual survival (S) and hunting kill rates (K)	Negative	No relationship for $K < c$	Intermediate between AMH and CMH
2. Nonhunting mortality after hunting season and K	No relationship	Negative relationship for $K < c$	Negative relationship but weaker than CMH
3. Nonhunting mortality and population density	No relationship	Positive relationship for $K < c$	Positive relationship but weaker than CMH

[a]Nichols et al. (1984: 541)
[b]Nichols et al. (1984: 541) modified by Caughley (1985); *see* text.

Evidence for CMH and AMH in Waterfowl

Nichols et al. (1984) provided a detailed review of the evidence for CMH and AMH to date for waterfowl populations. Most of the studies were directed toward mallards (Anderson and Burnham 1976, 1978, Burnham and Anderson 1979, 1984, Rogers et al. 1979, Nichols and Hines 1983, Burnham et al. 1984), although two were directed at diving ducks (Conroy and Eberhardt 1983, Nichols and Haramis 1980), and two (Geis et al. 1971, Blandin 1982, to be considered later) were directed toward black ducks. Most of these tested Prediction 1 using analyses of band-recovery data and generally supported CMH, although some analyses for young female mallards (Nichols and Hines 1983) and ring-necked ducks (*Aythya collaris*) (Conroy and Eberhardt 1983) supported AMH. More recent analyses of mallard data have provided some support for AMH (e.g., Caswell et al. 1985, Trost 1987), but still generally favor CMH (e.g., Trost 1987).

In our experience, managers have tended to focus on simplistic questions as to which of these two extreme hypotheses is "true." We believe that there are a number of fundamental problems with this emphasis. First, as noted earlier, there are differences in how each hypothesis is treated in statistical testing. Most evidence has centered on tests of Prediction 1, the relationship between K and S. In these tests, CMH corresponds to the statistical null hypotheses; thus, in order to reject CMH, one has to amass sufficient data to reject the hypothesis of no association between K and S. However, it may be difficult to detect even strong additivity using correlational methods, because sampling variation, environmental "noise," and inadequate replication may result in tests having low statistical power (high probability of Type II error). Improper attention to Type II error, for example by setting Type I error unrealistically low (say $P < 0.05$) could result in "experimental bias" in favor of accepting CMH. On the other hand, in Predictions 2 and 3, which generally have not been tested, AMH is the statistical null hypothesis. For tests of these predictions, "experimental bias" would tend to operate to preserve AMH as the accepted hypothesis.

A second problem is related to the fact that the AMH and CMH are extreme hypotheses, the former allowing no compensation among mortality factors, and the latter specifying complete compensation of hunting by other mortality. However, it seems unlikely that density dependence in waterfowl populations would be so strong as to completely compensate for hunting losses, and a partial compensation hypothesis (PCH) (Caughley 1985) may be closer to reality. Under PCH, there would be some effect of K on S below c, but the effect would be intermediate between that under CMH (no effect) and AMH (Figure 1c, Table 1). Previous researchers have recognized the biological limitations of AMH and CMH (cf. Anderson and Burnham 1976:41, Burnham and Anderson 1984, Burnham et al. 1984, Nichols et al. 1984) and have suggested that some form of incomplete or partial compensation is more reasonable than either extreme. Indeed, the slope of the relationship between S and K for mallard estimated by Anderson and Burnham (1976) was interpreted by Caughley (1985) as consistent with PCH, rather than necessarily supporting CMH. A problem with that interpretation is that unlike CMH or AMH, PCH is not a well-defined statistical hypothesis, which is why tests have focused on discriminating between AMH and CMH (Anderson and Burnham 1976, Burnham and Anderson 1984, J.D. Nichols pers. comm.).

A third problem relates to the mathematical form usually specified for CMH, in which compensation occurs below a threshold c, but for $K > c$ hunting mortality is additive (Figure 1b). There are two difficulties with this type of model. First, a sharp threshold for compensation may not be biologically realistic: c might be better represented by a region, rather than a point (Anderson and Burnham 1976:3, Nichols et al. 1984:538). The second difficulty involves the logic of testing AMH versus CMH in the absence of *a priori* specification of c. For example, in order to test Prediction 1, in which CMH is the statistical null model, one must assume that $K < c$. However, if kill rates really exceed c (whose value is unknown) then CMH may be rejected when it is really true (for values of K below c). We are unaware of any analyses in which inferences about the threshold and slope of CMH have been independently addressed, although colleagues in this area recognize the problem (J.D. Nichols pers. comm.).

The artificial simplicity of AMH and CMH, together with the intermediate model PCH, present further problems in biological realism. It is tempting to seek one model that "explains" the role of hunting in waterfowl populations, including those of black ducks, but a thoughtful consideration of the complexity of factors within and between populations should give one pause. These simplistic models do not incorporate the tremendous temporal variability and spatial heterogeneity known to occur in environmental conditions in North America, and which may in some cases override changes in "controllable" factors such as hunting rates. It is probably unreasonable to assume that the relationship among mortality factors, and in particular the effects of density on mortality rates, is the same in all subpopulations of a species over all years (Anderson and Burnham 1976:3, Nichols et al. 1984:551). Finally, it is possible that compensation operates differently in species such as canvasbacks (*Aythya valisineria*) that have relatively "K-type" life histories, than in species such as mallards that have relatively "r-type" life histories (Patterson 1979). We will return to these ideas later, when we present an alternative model for the effects of hunting on waterfowl populations.

The above discussion has concentrated on the effects of hunting on population growth through mortality rates. It is perhaps obvious, but sometimes forgotten, that populations grow or decline as a function of both birth and death rates (Johnson et al. 1988). It is entirely possible for hunting and other forms of mortality to be completely additive, but for populations to maintain themselves or even increase if reproduction rates exceed mortality rates, perhaps because of density-dependent recruitment (Errington 1945). For example, if the reproductive success of a waterfowl population is lower when densities of breeding birds are higher, then increases in over-wintering populations (brought about by decreases in hunting kill under AMH) could be compensated for by decreased recruitment the next year. The extent to which compensatory (density-dependent) reproduction occurs in black ducks or other waterfowl is unknown, although evidence from prairie breeding ducks suggests it may be partially density-dependent (Pospahala et al. 1974, Kaminski and Gluesing 1987).

A simple numerical example (Table 2) illustrates these points, using a hypothetical population that is harvested ($K = 0.5$), and two populations that are not harvested ($K = 0$), one in which mortality is density-dependent (CMH), but reproduction is density-independent, and the other in which mortality is density-independent (AMH), but reproduction is density-dependent. Note that the fall population levels for all

Table 2. Numerical example illustrating compensatory mortality and reproduction.

	A	B	C
Harvest rate (K)	0.5	0	0
Nonhunting mortality	—	Density-independent	Density-dependent
Reproduction	—	Density-dependent	Density-independent
Year 1			
Spring population size	100,000	100,000	100,000
Reprodution rate (Yn/Ad)	1.2	1.2	1.2
Fall population size	220,000	220,000	220,000
Number harvested	110,000	0	0
Winter population size	110,000	220,000	220,000
Winter mortality rate	0.091	0.091	0.5455
YEAR 2			
Spring population size	100,000	200,000	100,000
Reproduction rate	1.2	0.1	1.2
Fall population size	220,000	220,000	220,000

three remain unchanged from year to year, regardless of the level of K, because of compensation. If reproduction were density-independent, population B would be greater than population A, because of the additive effects of harvest. In a real population, of course, mortality and reproduction rates would vary because of factors besides density, and at random, resulting in imperfect compensation in any one year.

Review of the Evidence for Black Ducks

Early studies of mortality and the effects of hunting were descriptive and involved estimates of overall mortality rates, with some attempts to describe mortality by subpopulations and to determine the proportion of mortality due to hunting. Bellrose and Chase (1950) estimated mortality rates for black ducks using band-recovery data and the life-table methods of Hickey (1952). Using similar methods, Schierbaum and Foley (1957) found evidence of greater hunting vulnerability in males than females, and greater in juveniles than in adults. Lemieux and Moison (1958) used banding data to estimate overall mortality rates of specific breeding populations and proposed excessive hunting mortality as a possible explanation for the higher mortality rates of one breeding population. Stotts (1959) confirmed the higher hunting vulnerability of juveniles but suggested that females might be more vulnerable than males. He also noted that local breeding birds received heaviest hunting pressure, and recommended delaying the opening of black duck hunting to allow dilution of the local breeding population with migrants, and closing the season early in winter to avoid interfering with courtship and pairing. Reed and Boyd (1974) examined the effects of opening weekend hunting on black ducks breeding in the St. Lawrence estuary and concluded that favorable hunting conditions can result in destruction of a large portion of local annual production.

Martinson et al. (1968) and Geis et al. (1971) were among the first to approach directly and quantitatively the issue of the effects of hunting on mortality in black duck populations. Using the composite dynamic (Hickey 1952) and relative recovery rate (Geis et al. 1971) methods to estimate mortality rates from band-recovery data, they found evidence that recovery rates of juveniles were higher under ''liberal'' than ''restrictive'' regulations; the results were ambiguous for adults. They also found a highly significant correlation between estimates of recovery rates (used as an index to harvest rates) and annual mortality rates, consistent with AMH. However, Anderson and Burnham (1976) and Burnham and Anderson (1979) showed that the analyses performed by Geis et al. (1971) were flawed because of deficiencies in the composite dynamic method, and because of sampling correlations among the estimators of total annual and harvest mortality. More recent analyses of band-recovery data by Boyd and Hyslop (1985), although based on modern statistical methods (Brownie et al. 1985), were erroneously used to support CMH in black ducks because of sampling correlations among the estimators (Conroy and Krementz 1986).

Blandin (1982) used modern statistical methods (Brownie et al. 1985) to estimate survival rates for black ducks from band-recovery data, and to explore the possible role of hunting in regulating black duck population. Estimated survival rates were similar in years of restrictive and liberal regulations, suggesting compensation. However, Blandin (1982) was not able to detect evidence of compensation by correlation analysis of preseason recovery rates (indices to harvest rates) versus ratios of early winter to late winter recovery rates of winter-banded birds (indices to over-winter survival). Further, circumstantial evidence suggested that the harvest of black ducks, especially of young, may have been excessive in local breeding areas. Blandin (1982) performed simulation analyses that suggested that, despite good annual production, insufficient recruitment of young to the breeding population is limiting population growth. He recommended delayed opening of hunting seasons to reduce pressure on locally breeding birds, reduced season lengths to reduce overall harvest pressure, and early closure of seasons during winter to reduce pressure on birds during the winter stress period.

Krementz et al. (1987) updated Blandin's estimates of recovery and survival rates and found similar patterns of age-specific, sex-specific, temporal and geographic variability, except that there seemed little evidence for Blandin's (1982) suggestion that harvest rates of males were higher than those of females. A relative lack of temporal variability in annual survival rates seemed consistent with CMH (Krementz et al. 1987). Nichols et al. (1987) concluded that black ducks have similar hunting and overall mortality rates to those of sympatric mallards, and suggested that interspecific differences in population growth rates are due to reproduction or immigration or both. However, Krementz et al. (1988) further investigated the specific role of hunting in annual survivorship of black ducks and found evidence that changes in harvest rates under different regulatory schemes resulted in a direct (i.e., additive) effect on survival of some black duck sub-populations, mainly of adult males and juveniles.

Intensive radio-telemetry studies of Atlantic coastal wintering black ducks (Conroy et al. 1989b), although not directed specifically at the question of AMH versus CMH, nonetheless may provide insights into important interactions among mortality factors, including hunting. First, certain components of the black duck population, especially juveniles and adults in poorer condition, seem more vulnerable to mortality, including that from hunting. This greater vulnerability seems to persist at least through winter. Second, environmental variability, especially the timing and severity of winter storms, influences both the temporal availability of habitat, including food and sanctuary, and the degree of physiological stress to which birds are subjected and the likelihood of mortality. Third, hunting pressure through much of the wintering period places additional stress on black ducks, especially those forced to move into new habitats because of changes in environmental conditions, and thus likely interacts with nonhunting mortality factors.

An Alternative Model for the Effects of Hunting

The above review of the effects of hunting suggests that the issue is far from resolved: we cannot describe the role of hunting as either additive or compensatory for all species of North American waterfowl throughout their ranges. Indeed, it seems likely that the strength of any compensatory (density-dependent) mechanisms varies across Anatidae, perhaps being similar within guilds of waterfowl species having similar life-history attributes (Patterson 1979, Nudds 1983). For example, mallards may be characterized as being "r-type dabblers" (Patterson 1979), occupying a broad ecological niche and exhibiting both high reproductive potential and high mortality rates. Canvasbacks (*Aythya valisineria*) on the other hand are "K-type divers," occupying a narrower niche and exhibiting both lower reproductive potential and lower mortality rates than mallards (Patterson 1979). Herein we use "r-type" and "K-type" as descriptors of suites of life-history characteristics, rather than the terms "r-" and "K- selection," which imply evolutionary mechanisms that have not been empirically demonstrated (Stearns 1976, 1977). Assuming that waterfowl can be accurately ranked on an "r-K" continuum, differences in life history result in differing predictions about the respective effects of hunting for each species. First, mallards (and other "r-type" species), having greater mortality rates in the absence of hunting, have a greater potential for compensation than do canvasbacks (and other "K-type" species). The upper limit for c, the threshold beyond which K becomes additive under CMH, is $1\text{-}S_0$, the mortality rate in the absence of hunting (Nichols et al. 1984:538). This is because compensatory decreases in nonhunting mortality factors can only occur up to the maximum rate at which these factors operate in the absence of hunting; above that rate, increased harvest rates *must* be additive to other forms of mortality. Second, for $K < c$ we would predict that the strength of compensation would be greater for K-type species than for r-type species, because of the greater importance of density-dependent factors in the former group. Thus mallards should exhibit a greater threshold to hunting than canvasbacks ($c_{\text{mall}} > c_{\text{canv}}$), but when $K < c$, canvasbacks should exhibit more perfect compensation than mallards. We think that this conceptual framework is useful in generating testable predictions about the forms of compensation in species having different life histories (for example, that the threshold for canvasback is lower than that for mallards), although we agree with Nichols (in press) that such predictions are not unambiguous with respect to the ability of these species to withstand hunting mortality.

Within a species, we would predict that the potential for compensation depends to a great extent on temporal and geographic variation in environmental factors that influence mortality rates independently of population size. For example, one population may winter in areas in which catastrophic, weather-related die-offs occur every three to five years. Such phenomena are unpredictable and may be largely density-independent: The mortality risk from these factors does not depend on whether N is high or low. In years or areas where these phenomena are important, we would predict that the potential of the population to compensate for hunting mortality would be lower, because the density-independent mortality would compete directly with hunting in an additive fashion, leaving less potential for density-dependent (compensatory) mortality. The effect would be to reduce the threshold based on life history, perhaps to zero in some cases. Thus, there may be some years in which a population has no ability to compensate for hunting mortality, even though on average it exhibits at least partial compensation.

The above ideas lead to modification of the extreme hypotheses of complete additivity (AMH) and complete compensation (CMH) to allow for (1) a threshold value whose maximum (c_{max}) is determined by the life- history characteristics of the species under consideration, but whose realization (c_i) is influenced by temporal or geographic variation in environmental variables; and (2) partial compensation (PCH) below c_i, varying from nearly perfect for K-type species, to relatively weak for r-type species. The relationship of annual survivorship (S_i) to kill rate (K_i) under this model is illustrated in Figure 2.

The role of hunting in black duck populations should be reconsidered in light of the above revised model. Data on life-history attributes of black ducks is incomplete; for example, we do not know what "natural" mortality rates (in the absence of hunting) are for black duck populations. However, black ducks appear to have lower annual recruitment rates than mallards (Dennis et al. 1984), and black duck young grow more slowly than mallard young (Barnes 1988), both traits suggesting that black ducks may be relatively more "K-type" than mallards. This in turn suggests that black ducks have a lower c_{max} than do mallards, but below c_{max} compensation is stronger for black ducks. Sympatric mallards and black ducks apparently have similar survival and harvest rates (Nichols et al. 1987), but because both species are currently hunted, data on relative S and K are not helpful in determining natural mortality rates in the absence of hunting (and thus c_{max}), without a knowledge of the form of the relationship between S and K (AMH, CMH, or PCH). Second, black ducks appear to exhibit higher fidelity to wintering areas than do mallards (Diefenbach et al. 1988), the latter exhibiting more flexibility in dispersing from areas affected by severe winter weather. The timing and severity of winter storms, particularly those involving extensive icing, can have a dramatic effect on the winter survival of black ducks (Conroy et al. 1989b). Juvenile black ducks, and those in poorer condition, appear to be at greater risk (Conroy et al. 1989b), suggesting the involvement of a density-dependent mechanism (e.g., competition for limited resources) in predisposing certain components of the population to such risk factors. It is also possible that in other years severe or catastrophic weather has a non-selective and density-independent effect on mortality. Thus in some years black duck populations might be subject to a greater risk from density-dependent factors (with a correspondingly higher threshold in their tolerance for hunting), while in other years density-independent factors could be more important (with a correspondingly lower threshold) (Figure 2b).

The results that the effects of hunting may be variable both geographically and temporally (Krementz et al. 1988) are consistent with the above conceptual model. Adult male and young black ducks may exhibit more of an additive response to hunting than do adult females (Krementz et al. 1988), predicted because female ducks generally have higher natural mortality rates than do males, leading to a lower threshold to hunting for males. In any event, results of an ambiguous and sometimes contradictory nature can be expected if one were attempting to test AMH versus

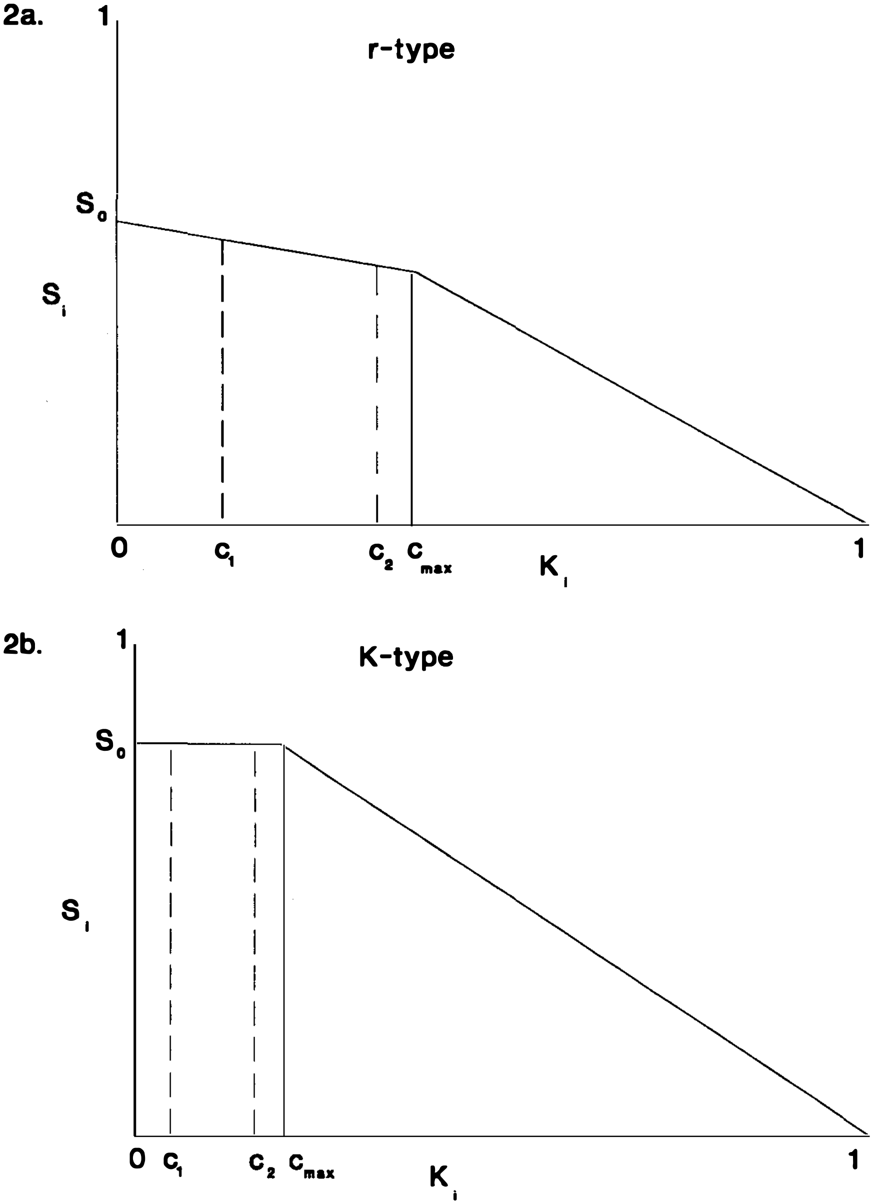

Figure 2. Relationship between hunting kill rate (K_i) and total annual survival (S_i) under the revised model allowing for differences in life-history attributes and environmental variation. S_o = theoretical survival rate in the absence of hunting; c = threshold beyond which K has additive effect on S; c_{max} = theoretical limit to c, equal to natural mortality in the absence of hunting ($1-S_o$); c_1 and c_2 are realized threshold values, under scenarios in which environmental variability results in higher risk due to density-independent factors in some years (c_1) and to density-dependent factors in other years (c_2). Note that the figures are drawn to illustrate the additive decline of S to O, with $K > c_{max}$; for c_1 and c_2, S will similarly decline to O, with the threshold occuring at S_i instead of c_{max}.

CMH, when in fact PCH with c modified by life history and environmental variability was more realistic.

We note that, while the above approach may provide some biological realism not provided by AMH or CMH, we are not satisfied with this ''solution''. PCH, unlike AMH or CMH, is not a ''well-defined'' hypothesis. Virtually any result intermediate between the two extreme hypotheses would be ''consistent'' with some form of PCH (as modified above) (J.D. Nichols pers. comm.). Thus, its utility in discriminating between alternatives may be limited to cases where clear-cut predictions can be made, for example in the rankings of the slopes and threshold values of PCH for mallards and canvasbacks as discussed earlier. Within a species such as black ducks, AMH and CMH are still logical endpoints in the relationship between S and K. However, once a completely additive model is excluded (as it will be in most cases), the problem is then one of estimating the strength of compensatory relationship (i.e., the slope between S and K, b) and the threshold (c) beyond which hunting mortality is mostly additive. Methodology for the former problem has been developed (e.g., Anderson et al. 1982, Burnham et al. 1984) in cases where one can assume that $K < c$. Two-phased regression (e.g., Nickerson et al. 1989) may be useful for the problem of simultaneously estimating c and b from observations on hunting kill and annual survival rates. However, we believe that these and other analytical methods will be of limited utility until controlled experiments on the effects of hunting are conducted.

An Experimental Approach to Determining the Effects of Hunting

The principal methods for examining the effects of hunting on waterfowl populations, including black ducks, have involved retrospective analyses of band-recovery data, mostly to test Prediction 1 of CMH versus AMH. Although these analyses have been useful, they have not yielded unambiguous answers to the question of the effects of hunting on annual survivorship. As discussed above, part of the reason is that simple, unambiguous answers probably do not exist. An additional problem is that previous approaches have lacked two features necessary for a proper hypothesis test: experimental control and replication (Hurlbert 1984, Nichols and Johnson 1989). Anderson et al. (1987) recommended an experiment in which black duck hunting seasons would be deliberately closed and re-opened to evaluate the effects of hunting on annual survival. The experiment would be conducted over 7–10 consecutive years and would involve two to three years of closed seasons. Banding would be replicated over several geographic areas, and customized statistical programs (White 1983) used to test whether annual survival rates increased in years of closed hunting (consistent with AMH) or on average remained unchanged (consistent with CMH).

We concur with Anderson et al. (1987), except that we would be interested not in simply discriminating between AMH and CMH, but in (1) estimating the threshold value c and if possible estimating year-to-year variation in c, (2) estimating the slope of the relationship between S and K under PCH and (3) estimating the strength of compensatory mortality mechanisms in black ducks, i.e., Predictions 2 and 3 appropriately modified under PCH. To accomplish these goals, we offer several modifications to the experiments suggested by Anderson et al. (1987).

First, we believe that simple "open" (under current, somewhat restrictive regulations) versus "closed" experiments may be inadequate to estimate the relationship between hunting mortality and survival for black ducks. We suggest that more than two levels of "treatment" (i.e., open season) including *liberalized* bag limits and season lengths in some years, are needed to estimate adequately the response of black duck populations to changes in hunting rates. Liberalized versus closed seasons would provide the greatest possible contrast in harvest rates, thus improving the statistical power of detecting an additive effect if it exists. This scenario may have attraction to policy makers in persuading sportsmen to give up black duck hunting in some years in exchange for greater opportunity in others. Second, we believe that any realistic experiment must include at a minimum an entire flyway, including the Canadian portions, to provide a meaningful change in overall mortality due to hunting. Third, we anticipate that environmental variation will play an important role in determining mortality, especially from nonhunting sources. Therefore, we suggest that 2 to 3 years of closed season may be inadequate to reflect this variability, and propose at least 5 years of closed seasons in an overall experiment of 10–15 years duration. Several years of closed seasons would allow estimation of variability in natural mortality rates in the absence of hunting, and hence in the potential for compensation (c_i).

Fourth, we believe that it is absolutely essential to examine not only Prediction 1 (the relationship between S and K), but Predictions 2 (K vs. nonhunting mortality rates [V]) and 3 (population size [N] vs. V). We would predict that for $K < c$, a fairly strong relationship exists between V and N, and in turn between K and V (Table 1, Figure 2b). Concurrent studies should be conducted to estimate V and N in important areas throughout the range of the experiment. Radio-telemetry (Conroy et al. 1989b) and intensive banding studies at more than twice per year (Blohm et al. 1987) could be used to estimate the former, while aerial surveys (Conroy et al. 1988, Canadian Wildlife Service unpublished data) and ground surveys could be used for the latter. Concurrent field studies could also address the impact of hunting on local breeding populations (Lemieux and Moison 1958, Stotts 1959, Reed and Boyd 1974), pairing (Stotts 1959), and migration and physical condition (Conroy et al. 1989b). Additionally, methods to monitor the rate of illegal kill of black ducks are needed to avoid possible misinterpretation of the results of the experiment. For example, if legal kill rates are reduced and annual survival is estimated using band-recovery methods, any increase in illegal kill will appear as "nonhunting mortality" in the estimates. In the worst-case scenario, if all hunters who would have legally shot a black duck instead shoot one illegally, annual survival rates will not have changed between open and closed seasons, leading to the false conclusion that CMH is true.

Finally, although the above discussion (and most analyses) have focused on mortality, the possibility that black duck populations compensate for hunting through increased reproduction should be tested. The proposed experiments would enable testing predictions of compensatory reproduction, especially because expanded breeding ground population and production surveys will be in place within the next one to three years (Canadian Wildlife Service unpublished data). These improved surveys, in conjunction with better representation of breeding areas in preseason banding efforts (J. Serie pers. comm.) should provide some of the basic population monitoring needed to evaluate properly the proposed experiments.

Conclusions

We began this paper by suggesting that managers of black duck populations in North America find themselves in a dilemma. They have inadequate scientific evidence to determine whether hunting is an important factor contributing to black duck declines. Hence, they are at odds both with those who advocate "doing something" and favor further limiting the harvest of black ducks, and those who challenge them to prove that hunting is a factor in the decline. This presentation will likely frustrate them further, because we believe that we are no closer to "answering the question" than Geis et al. (1971) were nearly 20 year ago. In part, this may be because we have been asking the wrong question. The questions to us are, given the basic life-history characteristics of black ducks: (1) how resilient are they to changes in hunting pressure on average and (2) how subject is that resilience to temporal, geographic and demographic factors. These questions boil down to the strength of the compensatory relationship under PCH, the average threshold value (c) and variation in c. A further legitimate question is the role of reproduction in compensation: (3) if black ducks return to the breeding grounds at lower density (perhaps because of high harvest rates), do reproductive rates increase in compensation?

We may have further frustrated managers, but we also believe that we have shown them at least one way out of this dilemma. If properly designed experiments, such as those described above, are executed correctly, then those who have been urging action should be satisfied, because the action of closing black duck seasons (at least in several years) will have been taken. Those skeptical of the impacts of hunting will be vindicated if they are right and will benefit from increased opportunity in liberalized years. They will benefit further in the public's eye if seen as willing partners, rather than as recalcitrant doubters, in an evaluation of the effects of their sport on the resource. Finally, we as a profession will benefit, if we take bold steps to help the resource while at the same time objectively evaluating the effects of our attempts using the scientific method (Romesburg 1981, Macnab 1983, Nichols and Johnson 1989).

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Compensation in Free-ranging Deer Populations

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Concept of Compensation

The concept of "compensation" (i.e., that one mortality factor can offset or largely replace another) (Errington 1946) is soundly entrenched in wildlife biology and management. Indeed, most recreational hunting is predicated largely upon the concept of a "shootable surplus." This surplus may include animals that will die from other causes if not harvested and/or from subsequent cohorts that will not survive (be recruited into the population) if density is not reduced.

In the case of large herbivores, the concept of compensatory mortality has been integrated with yield theory to form the basis for sustained yield management (Caughley 1976, McCullough 1979). This application generally assumes that deer populations are inherently irruptive and limited by a more or less determinate carrying capacity (K) linked to the standing crop of forage (usually on winter range). It also assumes that K is relatively stable, that intraspecific competition for forage increases as K is approached, and this results in high natural, density-dependent mortality. Under those conditions, removal of the harvestable surplus reduces density and increases per capita forage availability, and thus survivability of remaining animals in a compensatory manner. In this context, "harvestable surplus" comprises any animals (without regard to sex and age) in excess of the number at which maximum, non-destructive use of forage plants occurs. Also, compensation can occur as increased survival of remaining animals or subsequent cohorts (i.e., "compensatory reproduction") (Swenson 1985).

Despite broad acceptance and application of the concept, the nature and occurrence of compensatory phenomena in wildlife population is not well documented. Wildlife ecology and management texts and reviews continue to describe compensation generally on the basis of Errington's (1946, 1956, 1967) original studies and writing, results of studies on effects of exploitation in various upland game bird populations and/or in theoretical terms using yield, survival and recruitment curves associated with logistic or stock-recruitment models (e.g., Caughley 1976, McCullough 1984, Peek 1986). Similarly, published studies or "tests" for compensation in large mammal populations (Kuck 1977, McCullough 1981, Swenson 1985, White 1989) have been inconclusive or contradictory. Overall, they do not provide compelling evidence to support general application of compensatory theory to management.

For example, even if documented for birds, there are obvious problems with assuming that patterns of "compensation" are similar between species with 50–80 percent natural mortality rates and large mammals with much lower natural mortality rates. Likewise, mortality patterns and rates often vary between sexes and among age classes such that one should not be treated like any other with respect to compensation.

Yield theory based on the logistic model relates primarily to dynamics of newly introduced populations or to populations recovering from drastic reduction and a series of years of very low numbers in relatively benign and stable environments. In contrast, management is usually directed at long-established populations wherein another body of theory may be necessary to explain population dynamics and regulation. Additionally, we submit that most free-ranging deer and other large mammals occupy variable (stochastic) rather than stable environments such that assumptions underlying current theory are seldom, if ever, met.

We studied population ecology and dynamics of three mule deer (*Odocoileus hemionus*) and two white-tailed deer (*O. virginianus*) populations in four broadly different environments for periods of 7–28 years between 1960 and 1987. The studies included monitoring population characteristics and dynamics (size, sex and age composition, fawn recruitment and adult mortality) and population-environment relationships. The five populations fluctuated, some widely, in size and composition and were subject to varying regulations affecting harvest of antlerless deer.

Our findings collectively provide basis for detailed analysis of density-dependence and compensation in deer. However, because of the breadth of these questions, we limit this discussion to the question of whether the concepts have practical application; i.e., do "compensatory" responses occur with sufficient consistency and predictability to be useful in management.

In analysis, we relate fawn recruitment (number per female in spring) and total yield (the total number of fawns recruited to spring) to population size or density. These data account for all types of compensation; i.e., recruitment to one year combines the potential effects of "compensatory reproduction" and "compensatory mortality." In addition, because recruitment was measured across the range of densities characteristic of the populations over time, the data also help evaluate the extent to which hunting mortality may "substitute" for natural fawn mortality.

Study Areas and Populations

The mule deer studies included: (1) a 28-year effort (1960–1987) in the Missouri River Breaks, a representative, 106 square-mile (275 km^2) river breaks type habitat in central Montana (Hamlin and Mackie 1989); (2) a 15-year (1973–1987) investigation in the Bridger Mountains, a representative mountain-foothill habitat in southwestern Montana (Pac et al. 1990); and (3) a 12-year (1975–1987) study in the vicinity of Cherry Creek, a representative prairie environment in eastern Montana (Wood et al. 1989).

In the Missouri River Breaks, mule deer population density fluctuated widely from 3.6 per square mile (1.4/km^2) in spring 1976 to 16 per square mile (6.2/km^2) during autumn 1983. At the same time, recruitment of fawns to one year of age varied from 6 to 103 fawns:100 adult females. Harvest rate of adult males ranged from 15 to 58 percent annually, but was near the mean of 37.5 percent during most years. Harvest rate of adult females was more variable, ranging from 0 to 30 percent annually, and averaging 11 percent.

Data on recruitment-density relationships in the Bridger Mountains are for the intensively studied Armstrong area occupying the northern half of the 72 square-mile (186 km^2) northwest slope population-habitat unit. Representative spring population densities varied from 7 deer per square mile (2.7/km^2) in 1977 to 13 per square mile (5.0/km^2) in 1984. Winter range densities were higher, ranging from 39 to 73 per square mile (15–28/km^2). Fawn recruitment ranged from 4 to 53 fawns:100 adult females during spring 1975 and 1981, respectively. Annual harvest of adult males and females averaged 54 and 2 percent, respectively.

Mule deer population densities on the 210 square-mile (543 km^2) Cherry Creek study area ranged from 0.8 per square mile (0.3/km^2) in spring 1976 to 7.5 per square mile (2.9/km^2) in autumn 1983. Recruitment to one year varied from 13 fawns:100 adult females in spring 1985 to 90:100 in spring 1979. Estimates of average harvest, obtained only during 1982–1986, were 58 and 21 percent for adult males and females, respectively. They were generally lower for both sexes from 1975 to 1981.

The white-tailed deer studies included: (1) a 12-year (1975–1987) study on the Cherry Creek area (Wood et al. 1989) and (2) a 7-year (1980–1986) study along the lower Yellowstone River, an 86 square-mile (224 km^2) representative river bottom habitat in eastern Montana (Dusek et al. 1989).

Population densities on the Cherry Creek study area varied from 0.15 deer per square mile (0.06/km^2) in spring 1987 to 2.1 per square mile (0.8/km^2) in autumn 1982. Fawn recruitment varied widely within a range of 24 fawns:100 adult females (1985) to 110:100 (1980) Hunting mortality, again measured only during 1982–1986, average 31 percent of autumn adult male populations and 28 percent for females.

Whitetail densities along the lower Yellowstone River ranged from 30 deer per square mile (11.6/km^2) in spring 1981 to 66.8 per square mile (25.8/km^2) in autumn 1983. Recruitment varied from 46 fawns:100 adult females in spring 1985 to 111:100 in spring 1981. Annual harvests removed an average 57.5 percent (38–69 percent) of all adult males and 20 percent (6–33 percent) of all adult females in autumn populations.

With the possible exception of white-tailed deer along the lower Yellowstone River, populations were studied intensively over most, if not the entire range of density fluctuations expected in each area. Within the range of observed densities, mule deer in the Missouri River Breaks and Bridger Mountains were generally considered and managed as being at or above K carrying capacity from the mid-to-late 1950s to the early 1970s. Whitetails on the lower Yellowstone River and both species on Cherry Creek were considered above ''economic carrying capacity'' (Caughley 1976) during 1982–1984.

Generally, all Montana deer populations, including whitetails on the lower Yellowstone (Swenson 1979, Dusek et al. 1989), were at recent lows during the mid-1970s. Similarly, all were at highs during 1982–1984, when deer numbers may have been near or at all-time peaks in central and eastern Montana (Mackie et al. 1985). All central and eastern Montana deer populations declined during 1984–1986, with the timing and degree of decline varying among populations; Bridger Mountain mule deer populations remained relatively stable during the period.

All populations were free-ranging, subject to natural predation, varying hunter harvests, emigration, immigration and environmental variation characteristic of the northern Rocky Mountains and Great Plains region. Environmental variation may have been most extreme at Cherry Creek (Wood et al. 1989) and in the Missouri River Breaks (Hamlin and Mackie 1989), though availability of agricultural forage to a portion of the deer on the Cherry Creek area may have ameliorated variability to some degree. In the Bridger Mountains, environmental conditions were generally favorable and stable during summer and harsh and variable during winter (Pac et al. 1990). High quality agricultural forages were generally available yearlong on the lower Yellowstone and apparently reduced much of the effect of natural environmental variation in the region on deer (Dusek et al. 1989). Agricultural forages were insignificant to mule deer in the Missouri River Breaks and Bridger Mountains. We were unable to document any significant winter forage limitation on any area. Contrary to many past assumptions, the well-being of deer on all areas could only be related to overall, yearlong conditions.

Patterns of Recruitment Relative to Population Size

Relationships between number of adult deer in each population in spring (the residual population Nt) and total number of fawns recruited into respective populations the following spring (Nt + 1) are shown in Figure 1. For deer managers concerned with harvest management, yield expressed as the total number of young recruited may be the most meaningful criterion to examine.

Yield generally appeared to peak at or near the highest density observed on each of the areas, but was extremely variable at all densities. Interpretation and conclusions may vary with environmental variability and length of study; however, it seems obvious that neither a precise nor even relatively general level of yield could be predicted based entirely on deer numbers or density.

Low yields at high adult populations coincided with severe environmental conditions on all of our study areas. The three lowest yields associated with high adult numbers (>1,000) in the Missouri River Breaks (Figure 1) in two cases occurred coincident with severe drought, and in the other with a severe winter following drought. Similarly, low yields at high adult numbers in eastern Montana mule and white-tailed deer populations were associated with severe drought conditions that prevailed in the region during 1983–1985. The lowest yield in the Bridger Mountain population occurred following an unusually long, severe winter. Thus, data points that gave greatest credence to a density-dependent interpretation were also influenced by density-independent factors.

The relationship between numbers of adult deer in residual populations and recruitment on a per capita basis is shown in Figure 2. The dashed line in the data for each population was calculated from the logistic model by assuming that highest recruitment observed occurred at the lowest density observed, and vice-versa. Thus,

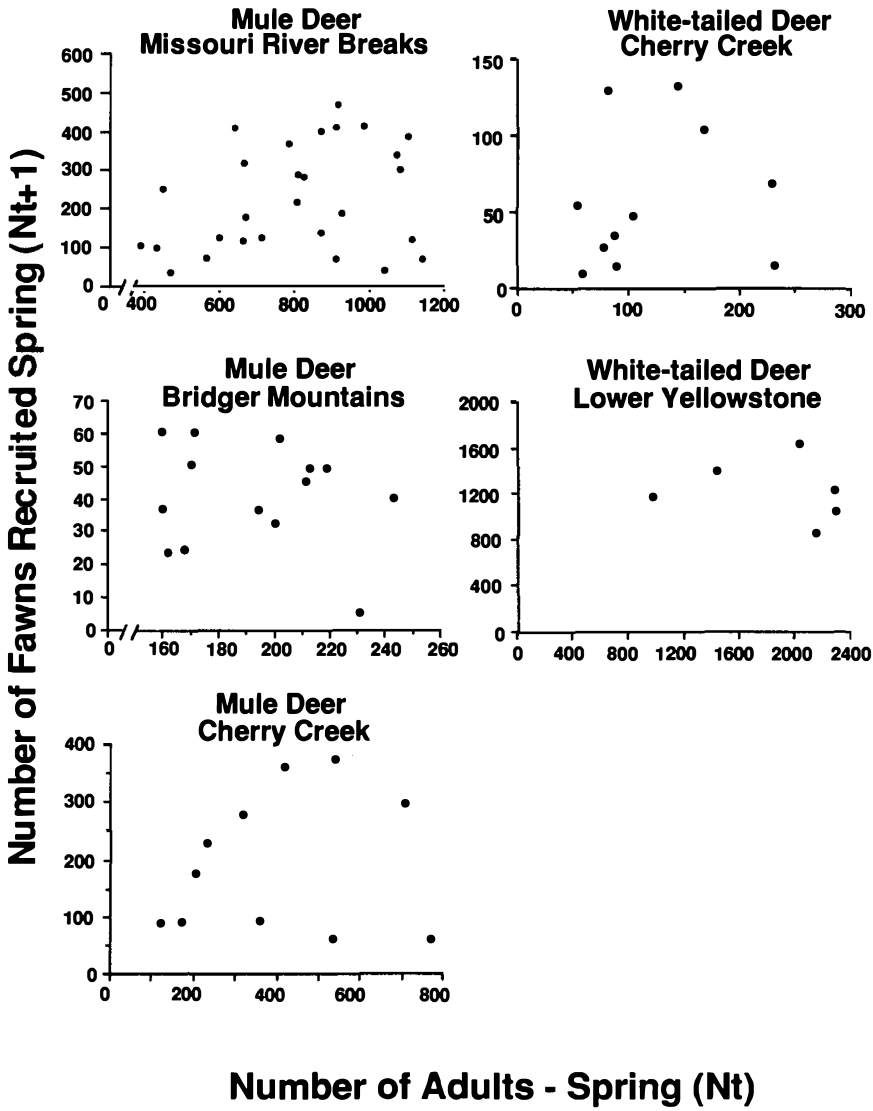

Figure 1. Yield in number of fawns recruited in spring (Nt + 1) plotted against the number of adults in the previous spring population (Nt) for five deer populations.

it represents the line along which each plotted point should fall if recruitment was inversely related to population size (density-dependent). The solid line represents the actual linear relationship between recruitment and adult numbers observed for each area.

Generally, correlations were low and insignificant for all areas and populations except for mule deer on Cherry Creek and lower Yellowstone whitetails. Despite

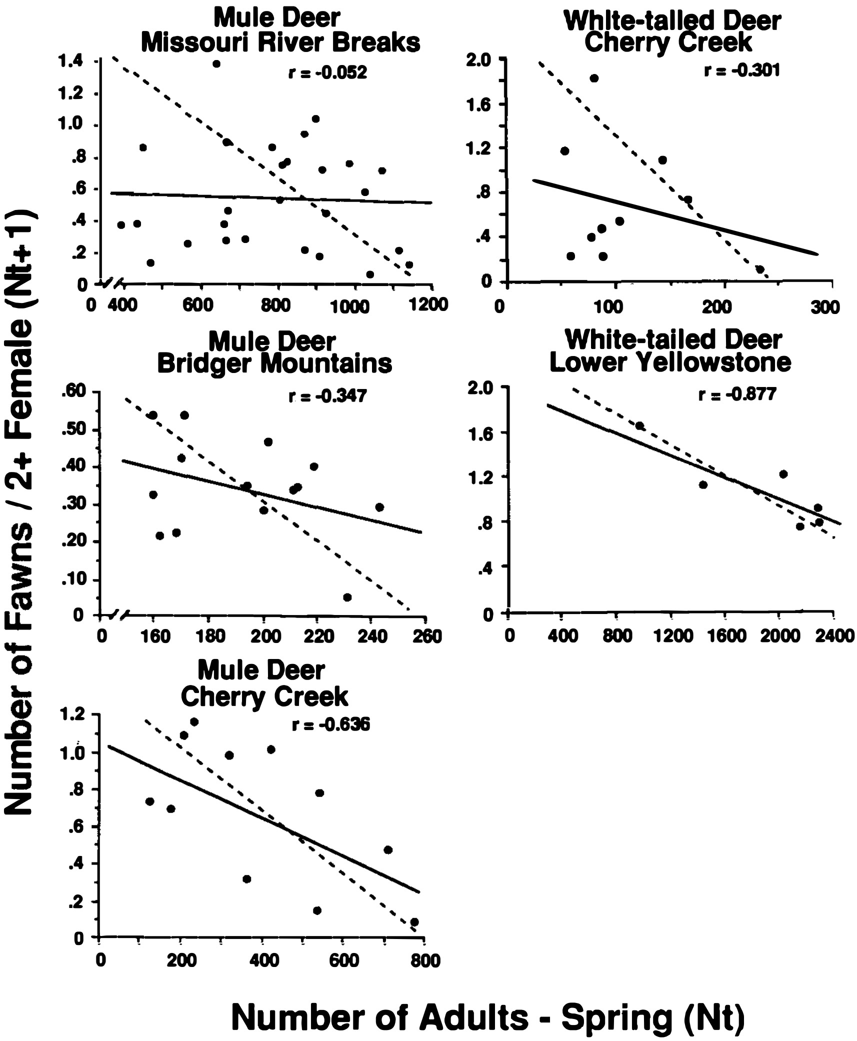

Figure 2. Relationship between the number of adults in spring (Nt) and per capita fawn recruitment (fawns:female two years and older) the next spring (Nt + 1) for five deer populations. Dashed lines represent theoretical maximum linear density dependence; solid lines represent the actual relationship.

the significant relationship for Cherry Creek mule deer, the coefficient of correlation (r) was relatively low (−0.636). The most significant relationships occurred where fewest years of data were collected and/or conditions were most stable. However, because the low per capita recruitment at high densities coincided with drought conditions in the region, more years of data may be necessary to confirm whether density was the determining factor. From a perspective of classical population theory, this may be moot because other data indicated that recruitment was associated with density of mature females in summer. Moreover, the limitation was behavioral rather than through forage available per capita (Dusek et al. 1989).

While we have presented data relating numbers of deer in residual/spring populations (Nt) to recruitment the following spring (Nt + 1) as most representative, we also examined relationships under various time-lag scenarios. Generally a one-year time lag strengthened correlations for all areas slightly, though not to the point of significance for the two areas with the longest data sets. For example, annual yield of fawns in the Missouri River Breaks with a one-year time lag (Nt + 2) still did not conform closely to that predicted by the logistic model and varied widely at all observed adult populations (Figure 3).

Discussion

Based on our data and experience, the academic possibility that density-dependent compensation may exist and contribute to understanding population ecology and regulation may have little meaning. Even irregular, intermittent or partial functioning of density-related compensation would not justify its application as a reliable "principle" for management of the five populations we studied. To assume its general existence and operation in population dynamics could result in misinterpretation of management opportunities and constraints.

In all populations monitored for any length of time, yield and per capita recruitment were extremely variable at all densities. The most nearly "traditional" relationship between density and recruitment occurred in populations followed for the shortest time and/or in the most stable environments. In western North America, environ-

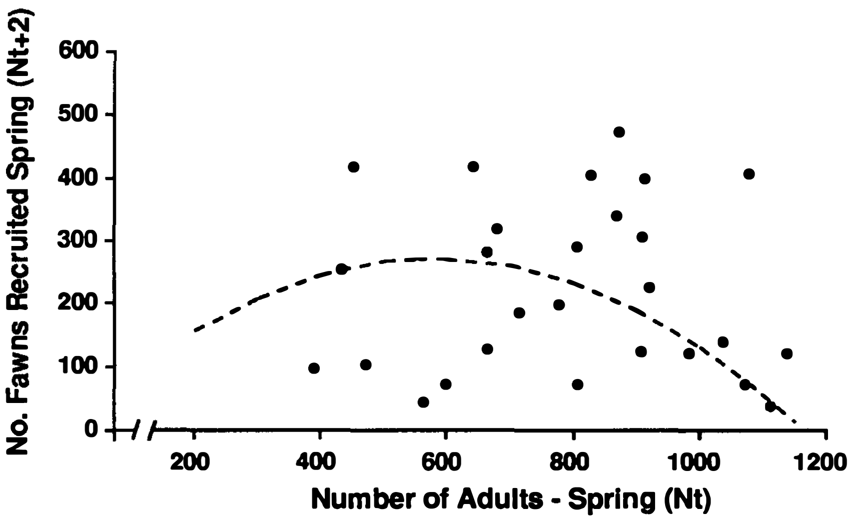

Figure 3. Yield in number of fawns recruited in spring (Nt + 2) plotted against the number of adults in the population two years prior to measured recruitment for Missouri River Breaks mule deer population. Dashed line represents the yield curve assuming maximum linear density dependence.

mental variation may be closer to the rule than the exception, even in what might be generally viewed as relatively stable habitats.

The range of densities that we observed for each population represents the general range within which any factor should operate to be considered practical for most management purposes. Densities near and lower than the lows observed for each area were generally unacceptable to hunters; those in the high ranges were generally unacceptable to landowners, and sometimes to us as deer managers. Thus, the possibility that density-dependent processes and compensation might operate or operate more consistently at lower or higher densities than those we observed would seem to have little practical application. Similarly, it is unlikely that management would often want to reduce population size or density much below the lows we observed from any area for any length of time. Therefore, even the possibility that density-dependence and compensation are more operational in pioneering populations [as suggested by Swenson (1985)] has little practicality for deer management.

Low production and survival were seldom the effect of undernutrition resulting from density-dependent intraspecific competition for food, especially during winter. Thus, we could not necessarily rely on high production at low densities. Also, high production, especially high yield in numbers, can occur at high densities. The lack of relationship between production/yield and density was at least partially related to the fact that "carrying capacity" fluctuated independently of population density. However, in the Missouri River Breaks, where forage production was measured over 11 years, fawn production/yield was also not related to *relative* deer density (forage per capita) (Hamlin and Mackie 1989).

Management policies based on the general assumption that intraspecific competition for food and density-dependent processes, including compensation, always operated, in all populations at all levels, may have contributed to widespread declines in mule deer populations during the late 1960s and early 1970s. This certainly seems to have been the case in Montana. When fawn survival dropped, we assumed that population reductions were necessary to increase forage per capita and nutritional level of deer on winter-spring range. Heavy harvest continued, fawn survival remained low, and populations continued to decline. In hindsight, it seems apparent that low fawn survival was not the result of density-related undernutrition. Therefore continued reduction of populations by hunting did not result in compensatory increases in survival and reproduction, but rather in continued population declines.

All of this indicates that deer management, especially in variable environments, must employ a strategy of annually monitoring population size and performance, as Caughley (1977) suggested, rather than relying on the predictive capability of classical theory. The alternative would be to employ relatively conservative harvest strategies, particularly when populations appear to be low and/or declining.

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Testing for Compensatory Responses to Removals from Wildlife Populations

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Introduction

Sustained exploitation of wildlife populations depends upon the ability of those populations to compensate for exploitation losses. Unless an unexploited population normally has a finite rate of increase greater than 1, other loss rates and/or recruitment rates must change for compensation to occur. Completely compensatory mortality has been defined as a process whereby exploitation below a certain level (the threshold point) does not decrease the annual survival rate of the exploited population (Anderson and Burnham 1976). Survival remains constant through a decrease in other forms of mortality. In contrast, additive mortality implies that exploitation adds to natural mortality, causing the annual survival rate to decrease.

I begin this paper by describing a study designed to test for compensatory responses. The design failed because a critical assumption was false. I then suggest ways to improve on that design, and discuss other possible designs for studying compensatory responses in survival and reproduction to removals from wildlife populations.

Rock Dove Study

In 1981–1983, we conducted a field experimental study on feral rock doves (or pigeons, *Columba livia*) in rural areas near Ithaca, New York. Four populations were studied: a control and populations harvested at low, medium and high rates. We trapped and marked a portion of the pigeons in each study area with patagium tags. We counted the pigeons once a month, recording the number of birds and the tag numbers of tagged birds. Using these data we computed mark-recapture (Seber 1982:204) estimates of survival, population size and number joining the population. We also monitored a portion of the nests in each study area and estimated egg and nestling survival using Mayfield-type estimators (Bart and Robson 1982). This design was intended to allow testing two hypotheses about differences among the four populations: (1) survival rates of adults remaining in the populations after harvest were not different and (2) egg and nestling survival rates were not different. Rejection of hypothesis (1) could imply compensatory mortality and rejection of hypothesis (2) would imply density-dependent nest success (Kautz 1985). Original plans called for replicates of each population, but we dropped them because of cost. We estimated the number of tagged birds needed in each population for adequate precision of parameter estimates, and we tried to maintain at least that many tagged birds in each population.

Unfortunately, there were significant pre-harvest differences among the four study areas in survival of eggs and nestlings and survival of adults. We didn't anticipate these differences, and our study design assumed that all four populations had similar survival rates and nest success in the absence of any harvest. Perhaps the populations were at different densities relative to food and cover. This problem caused me to examine the testability of the compensatory mortality hypothesis.

Problems with the Compensatory Mortality Hypothesis

One problem with the compensatory mortality hypothesis as formulated by Anderson and Burnham (1976) is that it is divorced from a mechanism of compensation. The only reasonable mechanism I know of to explain compensatory mortality is density-dependent mortality (Anderson and Burnham 1976). If density-dependent mortality is the mechanism, the compensatory mortality hypothesis (Anderson and Burnham 1976) assumes that nonharvest mortality rate is a strictly increasing function of density (Figure 1, line A). If this assumption is valid, testing for differences in survival rates between populations undergoing different harvest treatments is difficult without information about pretreatment and post-treatment population densities. If these assumptions are valid, most recent waterfowl studies on compensatory mortality (Nichols et al. 1984) implicitly assumed that pre-hunting season populations were at similar densities relative to resources important to mortality. While this may be

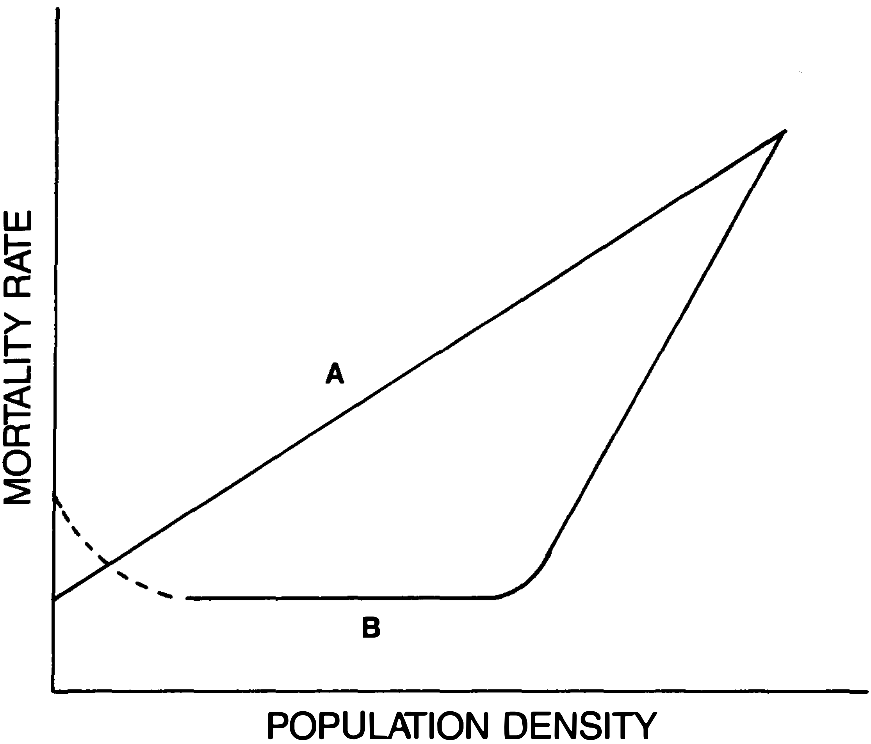

Figure 1. Hypothetical functional relationships between nonharvest mortality rate and population density (*after* Murray 1982:370).

a reasonable assumption for studies on large populations, it may not be reasonable for studies on small localized populations.

Further complications arise if nonhunting mortality rate is not a strictly increasing function of density. For example, Murray (1979, 1982) suggested that a line similar to B (Figure 1) is a better representation of the functional response of mortality to increased density. Though his assumptions explaining this relationship were more restrictive, a response of this form is reasonable if we assume that animals survive at some constant maximal rate at intermediate densities (where all habitat needs are met), and that mortality probability is higher at higher densities (where access to resources is more restricted). In some species, mortality rate might also increase at very low densities due to loss of social advantages in obtaining food or avoiding predation. If curve B (Figure 1) applies to a species, we would expect mortality to be compensatory only above some upper critical density.

Another complicating factor is that decreased density in a population with density-dependent birth rates will result in a changed age structure. If mortality rates in such a species are age-specific, overall mortality rates following exploitation might change without any changes in age-specific rates.

Considerations such as these suggest that the concept of compensatory mortality is useful only if it includes more explicit consideration of the mechanism involved. We should estimate age-specific mortality rates, and, unless precise control of density is possible, we should be testing for density dependence in these mortality rates.

Study Designs

Design Considerations

Variable measurement. To study density-dependent mortality or recruitment, one must measure population density. This requires some measurement of population size and relevant habitat resources. It will not usually suffice to measure just the area occupied by a population because habitat components per unit area may vary between areas and over time in the same area. This is what made population density calculations unwise in our pigeon study. I knew the approximate area occupied by each population we studied, but I was pretty sure the density of food, nesting and roosting resources were not similar in each study area. Since we made no measurements of pigeon food, nesting or roosting resources, I didn't calculate population density.

Selection of habitat variables to measure is critical. They should be variables known (or thought) to influence the dependent variable studied. Since some variables likely to influence reproductive success (e.g., availability of nest sites) may not also influence mortality, one may need to measure different habitat variables to study density-dependent mortality than to study density-dependent reproduction (J. D. Nichols pers. comm. 1990).

Because population density is a ratio between two variables each estimated with some variance, it is statistically less tractable than a population size estimate by itself. Ratios usually are more variable than the parameters used to compute the ratio, ratios are rarely distributed normally, and a ratio of two unbiased estimates may be a biased estimate of the ratio (Green 1979). This complicates testing. However, the advantage gained in potential understanding of biological mechanisms makes use of the ratio worthwhile.

To study density dependence, it is also necessary to measure population losses and gains. Though some studies simply track changes in population density or size, evaluation of hypotheses such as density-dependent mortality and recruitment require separation of the death process from the birth process and measurement of survival and/or production (Anderson and Burnham 1976, Conley and Nichols 1978, Nichols et al 1984). If studying the response of wildlife populations to exploitation, it is desirable to measure exploitation rate.

The timing of variable estimates is also important. To study the effects of removals due to exploitation on survival, density should be measured just after harvest (or just before harvest, if harvest is measured or used to achieve a certain density), and survival following harvest should be estimated (Nichols et al. 1984). To predict harvest effects on reproduction, density should also be measured just after harvest, though density estimates at the start of reproduction might give better prediction.

Potential study designs. Experimental manipulation with controls, replication and randomization is probably the best design (Nichols and Johnson 1989), but may not be accomplished easily. This was the design attempted in our feral pigeon study, but we failed to replicate, and the populations studied weren't similar before treatment. Replication allows estimation of variability between different populations under similar conditions, and is a requirement for some statistical methods (e.g., analysis of variance). In studies of density dependence, true replication may be difficult because density is seldom under precise control of an experimenter. Replication of exploitation levels may be possible, but any density-dependent response of the population is a function of both pretreatment density and exploitation rate.

Other designs which are more constrained may be necessary when it's not possible to do manipulative experiments (Nichols and Johnson 1989). Before-after comparison of relative changes between a control and treatments (Green 1979) is the design I had to use for our feral pigeon study. We assumed the relative change in the control area in adult survival from pre-harvest to post-harvest was the predicted change in other study areas under the null hypothesis. This approach assumes that the same year-to-year changes in environmental variables occur in all study areas. If we had measured density, this approach should not have been necessary.

A worse potential design is a constrained study within one population in which different treatments are applied to the same population at different times, and there is no control area (Green 1979). This design assumes that year-to-year treatment effects are independent of other factors causing year-to-year differences in survival or recruitment. If only one population is studied, extrapolation to other areas is not statistically justified. This design can be improved greatly by long-term studies on several populations at once, with control and treatment alternated in each population. Such a long-term study in replicate populations with balanced treatments may be the best design (K. P. Burnham pers. comm. 1990).

Short-term Experiments on Small Populations with Replication

One of the best designs is several experimentally manipulated small populations (including a control) with replicates of each manipulation. The populations should live in similar environments so they are as similar as possible except for treatments.

Population parameters for one year can then be compared among those populations. It is necessary to estimate habitat and population size and express population density as a ratio between the two. One can then test for a relationship between post-harvest density and post-harvest survival. If a relationship is found, one can conclude there are density-dependent effects. By examining graphs of post-harvest mortality versus post-harvest density, one may be able to determine the shape of the relationship. Similar tests can be performed for a relationship between population density and some measure of production. Regression can be used for testing if independent estimates of population density, survival and production can be obtained. If there are several discrete density levels, contrasts using the methods of Sauer and Williams (1989, Hines and Sauer 1989) can also be performed. In a capture-recapture study such as our feral pigeon study, covariances between population size and survival rate estimates will complicate the analysis. The methods of Pollock (1982) overcome this problem (Nichols et al. 1984). An advantage of this design is having results in a relatively short time.

Long-term Studies on Replicate Populations

Another best design suggested by K. P. Burnham (pers. comm. 1990) is long-term studies on many populations, where control is alternated with treatment in each population. He recommends randomization and balance in the assignment of control and treatment years to the populations. One way to achieve that would be to use the same sequence of treatment and control years in each population (e.g., three years of control, three years of treatment, three years of control, etc.), but randomly assign populations to start the first year of study on a different year of the treatment sequence. As above, the populations should live in similar environments, and similar statistical methods can be used for testing. In addition, it may be possible to evaluate year effects using appropriate multivariate models for testing. This design has the advantage of evaluating how populations respond to varying conditions over a number of years, but it has the disadvantage of requiring a long time to get results. If enough areas are involved so replicates of all treatments are performed in each year, this design in the first few years will be the same as the previous one, and partial results can be had in a short time.

Survival Estimation Models with Survival a Function of Density

A number of computer programs for estimating survival rate allow some user control in specifying the model for estimating survival. One can make survival a function of an independent estimate of population density in these models. By testing against models which don't make survival a function of population density (using goodness-of-fit and likelihood ratio tests), one can test for density-dependent effects.

The first possibility involves capture-recapture studies. In this design a population is studied for many years using capture-recapture to estimate survival. An independent method is used to estimate population density. By comparing survival estimation models with and without a population density term, one can test for density-dependent survival (Clobert et al. 1987, Brownie 1987). To be a good study, population density needs to vary among years. This can be achieved by experimental manipulation of the population. Disadvantages of this approach are that many years of data are required and no between-population variability is present. Simultaneously studying several replicate populations will overcome the lack of between-population variability. This approach can be extended to use mark-recapture estimates of population density (Brownie 1987).

A second possibility involves the estimation of survival using radio-tagged animals. The same approach is used, except survival is estimated using data from radio-tagged animals and the estimation methods of White (1983).

A third possibility involves the estimation of survival using band recovery data. Again the same general approach is used, but survival is estimated using the methods of White (1983) or Conroy and Williams (1984). This approach can be used with waterfowl, with estimates of population density coming from the May Aerial Breeding Ground Survey (Nichols et al. 1984), though a more mechanistic evaluation would use an estimate of post-harvest density. However, definition of populations and implementation of consistent regulations throughout those populations would be difficult (Nichols and Johnson 1989).

Difference Equation Models with Density Dependence

Eberhardt (1988) suggests using difference equation models to test hypotheses. He suggests including herbivore population size and its vegetational food supply. One suggested model makes reproduction density-dependent, and another has density-dependent rate of population change. He suggests retrospective studies of ungulate populations to evaluate potential models for future hypotheses testing. Perhaps models such as these can be used to test density-dependence hypotheses. This approach requires absolute population, vegetation and removal estimates, and population density needs to vary among years. As above, many years of data are needed, and no between population variability is present.

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Detecting Density Dependence: Filtering the Baby from the Bathwater

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Introduction

There is debate about the importance of density dependence (DD) in the real world. Although there are many studies where change in a given parameter (e.g., embryo rates or age at sexual maturity), follows reduction in population density, unambiguous demonstrations of DD as measured by population growth rate are few, and there are many contradictory results. Debate about DD is healthy, but I am concerned about the narrow context in which it is being addressed. I fear that the baby may be discarded with the bathwater.

In this paper I will make three major points. First, excessively broad inferences are being made because our concepts of DD and density independence (DI) are too imprecise. This is not a new problem and many efforts have been made to clarify the concepts (Macfadyen 1963:153–157; Horn 1968). Nevertheless, reading the wildlife literature and recent conversations with colleagues convinces me that there still are many different interpretations of these concepts. Second, the operational test of the null hypothesis, i.e., that the population is DI, results in a disproportionate likelihood of failing to reject the null hypothesis (type II error) in cases where DD may be present. Third, valid testing of the null hypothesis forces a choice between mutually exclusive alternatives (i.e., concluding either DI or DD), whereas real populations contain elements of both DD and DI that are expressed in various proportions depending upon life history characteristics, density, heterogeneity and variability of the environment, and time lags. Finally, I will review the population and environmental circumstances that influence the outcome of the test of DD and DI.

It is my thesis that all vertebrate populations, when considered over longer ecological scales of time and space, show episodes that are predominantly DD, others that are predominantly DI, and intermixing of the two. Thus, tests of DD done over small time or spatial scales may reflect episodes in a population's history that easily may be misconstrued with reference to population behavior over more inclusive ecological scales.

Definitions

In this paper, I define DD as a negative relationship between the population growth rate (r) and population size (N). As used here, r is a per-capita rate of population change. It is not the constant r of the logistical model, often called r_{max}. In logistical model notation, the r used here would equal dN/dt/N. The conventional term, ''population growth rate,'' is used despite growth being a misnomer because r can be zero or negative. I define DI as either a constant or a random relationship of r over the range of N. I define inverse DD as a positive relationship of r on N. Most cases of inverse DD are short-term phenomena involving predator avoidance and they will not be considered further here.

Population growth rate integrates the three major variables that determine population change—birth, death, and movements (immigration or emigration), which in turn encompass numerous lower order parameters (age at sexual maturity, litter size, etc.). In this usage, r is the net, or bottom line rate of change and this net rate determines whether a population response to changes in N is DD or DI.

I define compensation as a change in any population parameter that is consistent with a DD response. Thus, if N were reduced and the age at sexual maturity subsequently declined, this would be considered compensatory. It would be consistent with DD, but not sufficient proof of DD unless all other things were equal (i.e., controls would be necessary to establish that other parameters remained unchanged). Compensation is comparatively easily documented, whereas the associated net change in r necessary to document DD is more difficult.

Conceptual Considerations

Source of the Behavior: Population or Environment?

Some of the confusion about DD arises from a failure to sort out attributes of the population from those of the environment. We must recall that the population, as an entity, has genetics, behavior, mobility, etc., that have evolved over eons. The environment is a separate entity with its array of separate populations of plants and animals, and its abiotic components of geology and climate.

If these two entities are not separated conceptually, empirical tests of DD will be plagued by faulty logic in which results are attributed to characteristics of the population when actually they are attributable to the environment. DD and DI are population responses to the environment, but they are characteristics of the population as expressed through physiology and behavior.

A better construct is to consider the logic of DD in two steps. In the first step the environment is held constant in order to isolate the behavior of the population over the scale of N from zero to maximum carrying capacity based upon resources (KCC) in the absence of environmental variation. Laboratory experiments with small organisms in bottles or aquaria (e.g., Pearl 1927, Smith 1963) and perhaps field experiments such as the George Reserve deer (*Odocoileus virginianus*) studies (McCullough 1979) are of this kind. Laboratory experiments literally hold the environment constant, whereas in field experiments, environmental parameters are only approximately constant, and seasonality is included.

Once the behavior of the population in a non-varying environment is established, then the impact of environmental variation can be addressed. A DD response of a population is more easily detected in an environment with variation that is small or moderate. Clearly the DD response of a population can be overwhelmed by wide fluctuations in the environment. One could say that a population in such an environment behaves in a DI manner, but it is more instructive to know that such a population is behaving in a DD manner, and that environmental variation is overwhelming those efforts. This population behavior was referred to as "centripitality" by Caughley (1987).

Alpha (Population) versus Beta (Environment) and Gamma (Measurement Error) Noise

Consider the DD versus DI question as a signal-noise problem. The only source of signal is the DD response of the population when in a constant environment. But no population performs perfectly. Even in the laboratory, each replication of the growth experiment will have a unique, albeit similar, result. Thus there is both signal and noise in the population in a constant environment, and this noise might be termed alpha noise to indicate that it arises from the population. The environment is the source of no signal, but is the source of a second noise, beta noise. A third, and often unacknowledged, source of noise is measurement error (gamma noise). Measurement error is seldom explicitly acknowledged, but in the field, both r and N are usually estimated because they cannot be measured accurately. If beta and gamma noise are not identified, variance due to beta and gamma noise is attributed to the population.

Whether or not an empirical test of DD will return a result of DD depends upon whether the signal > alpha noise + beta noise + gamma noise. If so, we conclude that the population is DD and if not we conclude DI. But the conclusion of DI that fails to distinguish alpha from beta and gamma noise leads to misleading interpretations of how such a system works, and forecloses thinking about management strategies for dealing with beta noise (Shepherd and Cauthley 1987, McCullough 1988).

An Artificial Dichotomy

The desirable recent emphasis upon strong inference in research (Popper 1962, Platt 1964, Romesburg 1981) unfortunately also has fostered the DD versus DI dichotomy. DD and DI are considered as mutually exclusive alternatives, and if one can conduct a valid hypothesis test, the correct alternative can be established.

Without denigrating the value of the strong inference approach, I would like to suggest that this dichotomy is artificial. I suggest that the relationship of r on N is at times predominantly DI and at other times DD, and often a confusing mix of the two. Consequently, even a valid hypothesis test may give a result that is divorced from a larger ecological context. This is sometimes referred to as a type III error, asking the question in the wrong way.

It is my view that all vertebrate population show both DD and DI relationships. This can be deduced from two first order principles. First, resources required for life are in finite supply. This means that r for all populations is limited at some point. The shape of the function between r and N can vary (see below), but that r will decline to zero or become negative at some value of N is axiomatic.

By the same token, no real environment is totally stable and beta noise will inevitably be introduced to the relationship of r on N. If beta noise is small, the DD function will be discernible. If beta noise is large, DD can be obscured or completely swamped.

It is my view that treating DD and DI as a dichotomy is diverting our attention from the more important task of understanding how populations response to change in size under a variety of circumstances from naturally stable environments to those with high beta noise. Both DI and DD are necessary to understand long-term trends, even for populations in highly variable environments, much as Caughley (1987) has shown for kangaroos. Management strategies are possible to use DD responses for exploitation or translocation at high populations, and to dampen the amplitude of population fluctuations (McCullough 1988), particularly if environmental variation shows trends. Protection of a population that is above carrying capacity is not going to prevent a decline, and one should remember the analogy of steering a car in the direction of a skid. It may well be possible to decrease the amplitude of population fluctuations by reductions in density.

Statistical Considerations

Influence of Beta and Gamma Noise on Hypothesis Tests

Assume that we are observing a population that does show strong DD (i.e., strong signal). If the beta and gamma noise are small, then the ratio of signal to noise is high, and small changes in *N* will be sufficient to demonstrate DD. However, if beta and gamma noise are great, a much greater range in *N* wil be necessary to detect the signal. Combinations of a weak signal and strong noise defy demonstration of DD. If we know nothing about sources of noise, and objectively test the null hypothesis, in most cases we will fail to reject the null hypothesis because the typically used alpha level (0.05) puts an enormous burden of proof on DD in the face of noise. Thus, this procedure leads to a high probability of failing to reject the null hypothesis, and accepting a false null hypothesis (Type II error). We will conclude that this population was DI, when in fact, the population is DD, but beta and gamma noise are obscuring that fact.

Furthermore, the regression model assumes that *N* is measured without error, only *r* being estimated with error. Thus, if data for which *N* has error is treated by standard regression, probabilities of the hypothesis test are biased. If the data are treated by Type II regression (Sokal and Rohlf 1969), there is a loss of power, which also reduces the likelihood of rejecting the null hypothesis.

Appropriate Null Hypothesis

This raises a philosophical question. Is the null hypothesis of no relationship between *r* and *N* the appropriate null model? Or should the hypothesis tested be DD according to predominant theory of the field (Pearl 1927, Leopold 1933)? Therefore, rather than *r* not different from 0, should the test be *r* not different from the negative slope appropriate to the case being tested? Note that the latter would turn the tables on burden of proof, and make it extremely difficult to reject DD.

I believe it is best that we retain the null test of *r* significantly different from *0* slope for three reasons. First, it is the appropriate statistical approach. Second, it does not require the all but impossible task of stating the appropriate negative value of *r*. And third, it places the burden of proof on DD and thus favors more conservative decisions about exploitation in cases of doubt.

Interpretation of Accepting the Null Hypothesis

Even the terminology "accept the null hypothesis" leads to mischief. It is commonly misinterpreted as meaning that DI holds. The recent emphasis on strong inference has been invaluable in emphasizing the need for hypothesis testing in wildlife research. The accompanying message, that knowledge is gained by disproof (i.e., through elimination of competing alternatives), is less well understood. It is necessary to remind ourselves that failure to reject the null hypothesis does not prove the null hypothesis. It means that it must be retained as a possibility, and subjected to continuing attempts at disproof.

Time Lags

Consider the case where beta noise is not random, but instead shows trends, e.g., series of drought years alternating with series of good years. Timing of alternating patterns can complicate greatly the test of DD and give contrary conclusions. For example, if a density reduction experiment was coincident with the onset of a drought trend, a decline in r might be observed in a population that was DD. This problem occurred in Kucera's (1988) study of mule deer (*Odocoileus hemionus*) in eastern California. On two adjacent wintering deer populations, one was subjected to an experimental reduction by antlerless hunting, and the other was used as a control. It was hypothesized that the embryo rate of the reduced population would increase because of DD. A series of drought years occurred coincidentally with the study period and both populations declined. The reduced population did not show an increase in embryo rate, but the rate remained approximately constant, whereas the embryo rate of the control population declined significantly. Thus, there was compensation. It is a useful result to know that the effects of drought can override DD. But is is also significant that the density reduction ameliorated the effects of drought, and this compensation suggests the existence of DD. Perhaps under even greater reduction the embryo rate of the reduced population might have increased. Note, also, that in the absence of a control, it would have been easy to conclude erroneously that the reduced population behaved in a DI manner.

Similarly, time lags in predator-prey systems can result in out-of-phase relationships between r and N that complicate detection of DD. Other lag problems relate to age structure in strongly K-selected species such as grizzly bears, elephants and whales. If density is reduced by removal of adults, there is a long lag in the response of r in these species due to delayed sexual maturity (McCullough 1986). Therefore, r observed immediately following the reduction invariably declines on a per capita basis. To be fair, the evaluation of DD in time-lagged systems must be lagged over at least one climatic or predator-prey cycle or the generation time of the population.

Influence of Scale

In the regression equation of r on N the Y intercept (a), varies relatively little because it is related to the physiological capability of the species. KCC, on the other hand, can vary greatly with size of the study area selected, and the greater KCC, the less the regression slope (b). Thus, assuming $a = 1$, if KCC $= 100$, $b = -0.01$, whereas if KCC $= 1000$, $b = -0.001$. If r is not scaled relative to N, as N becomes large, b differs so little from zero slope that even populations in environments with little variance will result in failure to reject the null hypothesis. It is not surprising, therefore, that most demonstrations of DD have been studies in laboratory containers or exclosures (such as the George Reserve), where KCC was small. To test the null hypothesis fairly, field studies must scale large values of N by means such as using population density instead, or the unit of area used for study must be selected carefully with reference to likely value of b.

Alternative Functions of *r* on *N*

The simplest case (e.g., the logistic model) is that *r* is linear on *N*. However, empirical work has shown that for many populations the relationship is nonlinear (Stubbs 1977, Fowler 1981a, 1981b). Although most nonlinear functions of *r* on *N* probably become curvilinear gradually, Stubbs (1977) has pointed out cases where there is not a transition, but rather an abrupt threshold; these are best treated as two separate segments, each with a linear fit. For purposes of illustrating the likelihood of outcome of a DD test, the two segment case is clearest and, thus, is used in the figure here. Such a curve has a linear segment with constant *r* ("plateau") that would indicate DI, and a linear segment of constantly declining *r* ("ramp") that would indicate DD. What are some of the variables that influence the likelihood of plateau versus ramp?

Scale

The importance of scale was discussed previously with reference to the slope of *r*. Scale also can influence the shape of the function of *r* on *N*. Consider white-tailed deer at the George Reserve where maximum (physiological) *r* was approximately one. Because KCC was only 176 head, the observed function of *r* on *N* was nearly linear (only slightly curvilinear) and entirely a ramp. Now consider if three identical adjacent areas were available and included in the study area. KCC would be 528 head, three times what it was. In this case, one would likely observe a plateau of *r* over some range of *N*, until resource limitations produced a ramp (Figure 1A). The scale of the George Reserve was too small for this plateau to be expressed, and only the ramp was apparent. In larger areas, ranges of *N* on the plateau would suggest DI. DD would be observed only at the higher *N*, where the ramp occurred, as opposed to over the full range of *N* on the George Reserve.

Environmental Homogeneity

Why, despite the small scale, did the George Reserve deer population not grow at a constant *r* until nearer KCC? The George Reserve is a heterogeneous area, and quality of possible deer home ranges declines rapidly in this small area where relatively few home ranges are available. Dominant individuals occupy the best home ranges, and other individuals are forced to occupy lower quality home ranges. Thus, relatively small increments of *N* result in declining average home range quality, and declining *r* (Figure 1B).

Suppose that the George Reserve were a perfectly homogenous environment. The quality of all possible deer home ranges would be equal, so occupation of home ranges by dominant individuals would not adversely affect other individuals. Because home range quality would not change with increments of *N*, *r* would tend to remain constant until KCC was approached, at which point it would drop precipitously (Figure 1B). Thus, the DD effect, rather than being a gradual reduction (a ramp) would be more of a cliff edge threshold. This DD effect is no less real or important, despite its abrupt transition. All empirical tests of DD, except those that included an *N* exceeding the threshold, would lead to the conclusion that the population was DI. Such a population would show catastrophic behavior, with all values of *N* below KCC being within carrying capacity, but the increment that pushed $N >$ KCC would be accompanied by a crash in *r*.

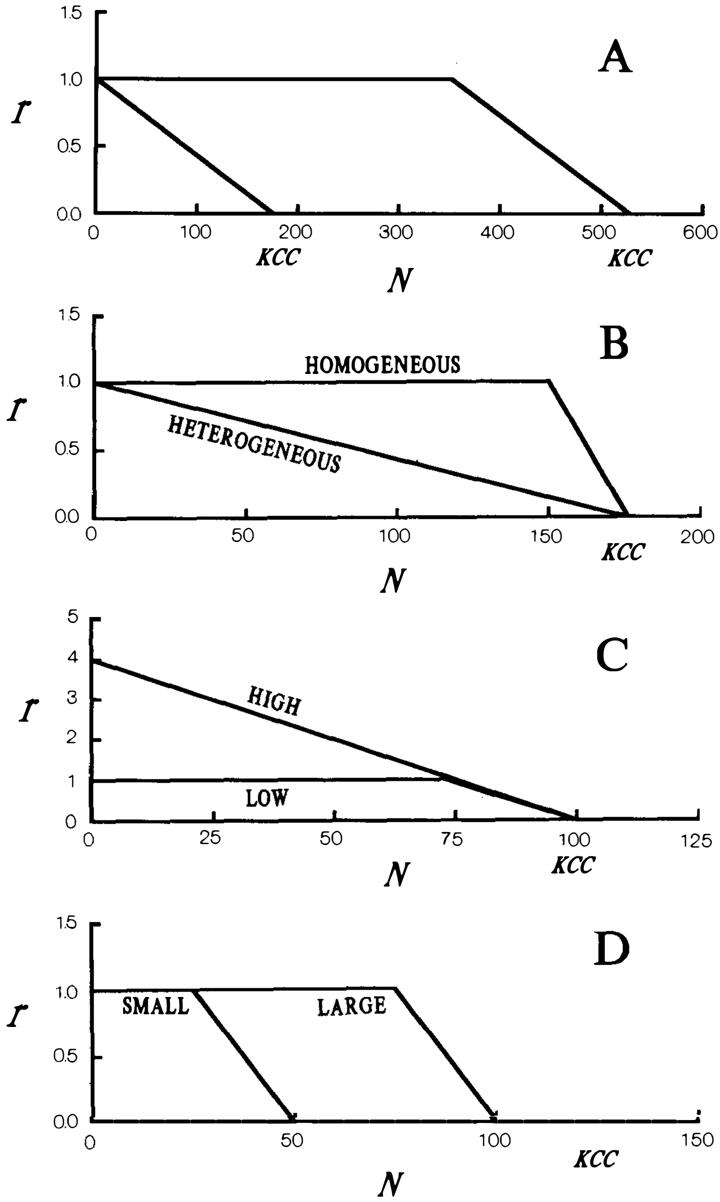

Figure 1. Some variables influencing the function of r on N and the likelihood of apparent DD (ramps) or DI (plateaus) in hypothesis tests over the range of N from zero to KCC. A. Scale: the right ramp assumes KCC of the left ramp was tripled for a population with a maximum r of 1.0. B. Heterogeneity of the environment. C. Life history: the upper curve is for a population with a high maximum r and the lower curve for a low maximum r. D. Refugia: the small refuge has little cover while the large refuge has greater cover, but both set limits below KCC. See text for further explanation.

The environment of no species is perfectly uniform, but some, such as grassland ungulates, tend to be more homogeneous than others. Populations in homogenous environments are likely to show constant *r* (and DI) over greater ranges of *N* than are those in heterogeneous environments.

Life History

A species with large physiological capacity to reproduce can show pronounced response to changes in density. Thus, perturbations of density, whether experimental or due to beta noise, evoke a strong response. Species with little physiological range (e.g., litter size constrained to one) show much more muted response. The null hypothesis is much more likely to be rejected in studies of the former species than the latter, noise being equal (Figure 1C).

The position of *N* relative to KCC can also influence the test for DD. Stubbs (1977) and Fowler et al. (1981a, 1981b) have presented theoretical arguments and literature reviews suggesting that K-selected species show the strongest density-dependent response when *N* is near KCC, whereas r-selected species should show the strongest density-dependent response when *N* is low. Because of large birth weight and small litter size (often one), physiological and anatomical limitations exist on *r* for strongly *K*-selected species. Thus, once a stable age distribution has been achieved, growth from low *N* tends to be fairly constant for these species until KCC is neared, when decline in *r* occurs relatively rapidly. Conversely, strongly *r*-selected species produce massive numbers of offspring, the survivorship of which varies enormously. Thus, *N* over time shows considerable variation. If this variation were literally random, extinction probability would be extremely high. Persistence of these populations is dependent upon survival not being random when *N* is low; i.e., DD tends to operate strongly at low density, and this offsets extinction probability.

However, it can be argued also that density effects may be stronger at the other extreme (i.e., *K*-selected species at low density and *r*-selected species at high density). Whereas resource limitations are strongest in *K*-selected species at high density, at low density, refuge effects and scarcity may well moderate the impacts of predators and diseases. And, *r*-selected species, thought not to be resource limited, may exhaust resources during outbreak phases. These considerations suggest that for both *r*- and *K*-selected species, DD is likely to be greater at high and low densities than at moderate densities.

Behavior

As noted earlier, social dominance in conjunction with environmental heterogeneity could influence the shape of the function of *r* on *N*. Territoriality by defense of area, rather than resources per se, can dampen the effects of environmental heterogeneity. Species with resource-based territories are often thought to fit the cliff edge model described above. If territories were of fixed size in homogeneous habitat, or if territory size increased to include required resources, only so many territories could be fit into a habitat. Over broad ranges of *N*, *r* would be constant. The population would show apparent DI right up to the threshold of carrying capacity based upon number of territories that could be fitted into the area.

However, if territory quality varied, *r* would be expected to be DD over a range similar to that of a heterogeneous environment (Figure 1B) for the same reasons. A similar result would hold if territory size was compressible. Once the number of uncompressed territories was established, compressed territories would reduce the average quality of territories, and r would decline as a ramp, even if the environment were homogeneous.

Predation

Predators can hold prey populations below the limits of resources, and this can result in apparent DI in the prey. Conversely, predation rate may vary with N, and thus, contribute to DD in the prey population. Thus, predators can induce either DD or DI, depending on the situation.

In addition, refugia can influence DD relationships in the prey. Refugia refer to the existence of escape or concealment cover that renders prey species invulnerable to predators (Errington 1934). Populations of prey that can be encompassed in the refugium suffer low predation rates (DI), whereas greater populations suffer high predation rates (DD). If there are qualitative aspects to cover, r beyond the threshold of security will be a ramp; if cover is all or nothing, then r beyond the threshold will be a cliff edge. Because cover usually varies in quality, a ramp is probably more common.

The N that can be supported by cover may be a small fraction of, about equal to, or greater than N supported by resources. If cover is small compared to food resources, the plateau will be small relative to ramp, whereas if cover is more nearly equal to food resources, the plateau will be large relative to the ramp (Figure 1D).

Conclusions

I suggest that determination of DD and DI in real populations involves a complicated array of variables. The likely influence of some of these variables is predictable from theory. Simplified tests of DD may misrepresent this complexity and lead to conclusions that, although correct for the study circumstances, may be misleading about population behavior in a larger ecological context. Before the role of DD and DI can be assessed, studies of a population over a full range of densities are necessary to determine the function of r on N, and the possibility of time lags must be taken into account. Or, alternatively experimental approaches with multiple treatment levels spanning the function of r on N need to be pursued.

Circumstances surrounding the testing of the null hypothesis and unidentified noise result in reduced probabilities of rejecting the null hypothesis, and acceptance of DI. Thus, there is a heavy burden of proof on DD, and a hazard of throwing out the baby with the bathwater. Simplistic concepts and narrow conclusions constrain the search for management strategies appropriate to variable environments.

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Special Session 11.
Introductions and Reintroductions of Wildlife Populations

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What Have We Learned from 100+ Years of Wildlife Translocations?

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I have the distinct honor of introducing one of the most unique and thought provoking sessions scheduled at this 55th North American Wildlife and National Resources Conference. I want to express my thanks to The Wildlife Society and particularly my co-chairman, Dr. Clait Braun, for asking me to chair this special session—Introductions and Reintroductions of Wildlife Populations.

The last 100+ years of translocations have been bittersweet, as we have made some outstanding successes and some monumental blunders. As I look back over the last century, and particularly the last 30 years, it's apparent that we have made some of the same mistakes with different species throughout North America.

One thing we did time and time again over the last century was to alter the habitat and wantonly chase the remaining few individuals of a species till they remained in isolated, inaccessible pockets. We remember from our basic conservation courses where timber stands covering entire states, such as Pennsylvania, were unmercifully attacked with the axe and saw to feed a nation's appetite for lumber. Some animal species, such as the passenger pigeon, retreated until there was no place to go and were lost. We lost, with this insatiable and ignorant attitude, the opportunity to ever bring back a species that once numbered in the billions. The white-tailed deer, the wild turkey and other species were much more fortunate. Before we examine these successes, we need to examine the problems associated with translocating a species, from both the human and the species perspective.

First, we always seem to want a species we don't have because, as Durward Allen said in *Our Wildlife Legacy*, we have an appetite for the "Greener Grass." It didn't take the colonists long to get the urge for something new. Richard Bache, Ben Franklin's son-in-law, tried Chinese pheasants, via England, in New Jersey in 1790, the first of many such attempts. Later to follow were other species, including chukars and Hungarian partridge to the northern Great Plains. These successes whetted the human appetite to try other attempts using various species of birds and mammals.

Another human dimension is to simplify the whole translocation process. One basic error has been to move new species into an ecological situation devoid of checks and balances. Small numbers of European rabbits introduced over a century ago into New Zealand and Australia rapidly turned to millions, causing problems such as overcrowding and lack of food. Ditto with the red deer and white-tailed deer when they were translocated in New Zealand. The artificial propagation and translocation of many of the bird species were shortcut methods to establish populations.

Trap and translocation of some of our wildlife species also were welcomed by some people and became a dreaded nuisance to others. For example, the beaver's comeback following restocking in the 1950s in eastern North America has provided valuable wetland habitat for many species of waterfowl, herons, otters and muskrats. As timberland is lost and habitat flooded, some landowners wage a never-ending battle to eliminate beaver populations. The same is true with the introduced nutria, from South America, released in the coastal marshes of Louisiana. The value of nutria pelts amounts to millions of dollars to the economy, but what happens if fur prices reach low levels that make trapping unprofitable? Nutria overpopulations could have catastrophic effects on the coastal marshes of Louisiana.

Some of the translocation successes since the 1950s in North America have been phenomenal. We have populations of white-tailed deer, elk, resident Canada geese, bighorn sheep, pronghorn, and wild turkeys that were not thought possible when I began my career 30 years ago. It all happened because of improved capture techniques, trapping and moving wild birds and mammals into suitable habitats, and providing adequate protection until populations were established. Telemetry techniques in the last two decades gave us the opportunity to learn more about the biology of our wildlife species and how to manage them effectively.

The wild turkey restoration efforts have mirrored the mistakes and unbelievable successes of the trap and relocation programs seen with other species. Wild turkeys numbered about 30,000 birds at the turn of the century and those numbers increased slowly as the small, row-crop farms of the Depression Era reverted back to stands of timber. The get-rich approach for mass producing pen-raised stock and releasing hundred of thousands of inferior stock followed World War II. This approach with the wild turkey failed miserably, with millions of dollars wasted, as it did with coturnix quail introductions.

Along came the modification of the cannon net designed to trap waterfowl in the early 1950s, so birds could be trapped from existing populations by state agencies, and the slow restoration of suitable habitats began. In the 1960s, we were taught that wild turkeys needed 5,000–10,000 acres of unbroken habitat with a high percentage of that habitat in mast-producing trees. Obviously, the thriving population of 100,000+ wild turkeys seen today in Iowa, where only 4 percent of the state remains in timber, didn't go to the same school. The same occurred in the fragmented habitats from Pennsylvania to South Dakota.

Just two weeks ago, at the Sixth National Wild Turkey Symposium, I reported that the wild turkey population in the United States was about 3 million more birds than reported at the First National Wild Turkey Symposium, in 1959. The population has increased about 1 million over the last five years because of active state agency commitment to restore the birds to all suitable habitats. In fact, by the year 2000, the major restocking should be completed in the United States. Also note that we have wild turkeys now in every state except Alaska. This includes 10 states outside the species' ancestral range. Of the 49 states supporting wild turkeys, 47 have spring hunting seasons, with Delaware to join the ranks in 1991, leaving only Nevada without a spring season. This compares to only 20 states with hunting in 1959. The wild turkey is truly a modern conservation success story.

What about the exotics? Remember all of the different types of pheasants, like the Reeves, that were buzzwords of the 1960s? Where are they now? Gone, as they generally came from pen-raised stock and/or weren't suited for the environments in which they were released. Have we learned our lesson? Apparently not! Michigan is spending over $1 million to stock the Sichuan pheasant from eggs shipped from China. I fear that elaborate measures to propagate the birds, which supposedly will replace or crossbreed with the ring-necked pheasant, are part of one more chapter in our attempt to provide sportsmen something that probably is unattainable because of habitat changes and the use of artificially propagated game farm stock.

What about the sportsmen who take the trap and relocation situation into their own hands? We know that wild-trapped raccoons have illegally crossed state lines in the Southeast and that the coyote range is expanding at a rapid rate because animals are intentionally and illegally being moved to satisfy the whims of a few houndsmen. The short-term effects involve potential disease transmission, such as rabies, and in the long term, may displace fox populations, which might alter complex predator/prey relationships developed over millions of years.

The challenges of the coming decade are to put our native wildlife, both game and nongame, in all available habitats. The trick will be not to do it at the expense of existing wildlife species, but with sound biological and economical methods. Hopefully, we won't repeat our past mistakes and will not promise our sportsmen, who pay the bill, a panacea by stocking or translocating a species that has little or no chance of succeeding.

Our session today will address some of the various specific aspects, from the genetics to the politics of the trap and translocation approach. I am confident that, before we are through today, we will better understand the role trapping and translocating our wildlife species plays in the coming decade and the next century.

Public Attitudes, Politics and Extramarket Values for Reintroduced Wildlife: Examples from New England

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Introduction

The reintroduction of wildlife to areas where they had existed has been a major concern of wildlife biologists and naturalists throughout this century. Typically, reintroduction (which can be quite costly) has occurred when special interest groups have organized public support and the effort becomes politically feasible. Only recently have these efforts been analyzed in economic terms; that is, assessing the benefits and costs in a decision-making context. Unfortunately, the complex ecological-humen interrelationships that underlie wildlife viability do not lend themselves to analysis with traditional market-oriented measures. Market price is the conventional measure of value for private goods from shirts to sugar, but it often does not reflect the diverse public objectives for the management of common property resources such as wildlife. To help overcome some of the limitations, economists have devised elaborate techniques to infer market values indirectly for specific activities such as hunting. Less attention has been given to the value placed upon wildlife by people who are not direct users but who, nevertheless, have an interest in it. Current theory suggests wildlife values fall into two categories: (1) personal use values, including both current use and options to preserve the opportunity for future use, and (2) existence values, which take into consideration such motivations as altruism, including its intergenerational aspects, and intrinsic values (the ethical right of a species to exist apart from any benefit it offers man). In this paper, we examine these values and related attitudes for two species reintroduced to New England: the bald eagle (*Haliaeetus leucocephalus*) and the wild turkey (*Meleagris gallaavo silvestris*).

While biophysical interrelationships set limits of capability, managerial objectives for wildlife species also are determined by attitudes, perceptions and the economic value placed upon the species. Traditional measures of monetary value (market sales, economic impact and consumer surplus accruing to recreational users) may have validity in certain situations, but much of the economic value associated with wildlife originates with people who have limited personal contact with them. These values fall into the realm of extramarket values and include option and existence values.

Option values reflect the desire to retain the opportunity to use a resource in the future, although there is no plan for present consumption (Weisbrod 1964, Bishop 1982). Option value includes consideration for uncertainty since a program may or may not be successful in retaining a resource for future use, and the subject may or may not take the opportunity to consume it in the future.

Underlying motivations for existence values include the desire to assure the availability to certain resources for future generations (bequest values), to provide opportunities for others to benefit from them (altruistic values) and ethical concerns for the well-being of nonhuman elements in the ecosystem (intrinsic values) (Randall and Peterson 1984, Walsh et al. 1984). Since existence values do not involve the intent of personal consumption in the present, they are not included in demand curves and, thus, are not considered within the context of conventional economic valuation.

Existence values sometimes are defined to include only resource nonusers, but similar motivations can exist among those using the resources in a specific time period. An individual conceivably can value a resource for current use, wish to retain the option for future use, and be concerned with its existence for the benefit of others in both the present and the future.

While many wildlife reintroduction efforts have widespread public support, little information is available about the net benefits attributable to such efforts. Cost information is sometimes available but little has been done to determine the values associated with reintroduction. In many cases, traditional neoclassical economic analysis has not provided the basis to measure the magnitude and extent of public support. The bald eagle and wild turkey were chosen for the study since familiarity by the general population is helpful in securing the kinds of information desired, and both of these species are highly recognizable.

Wildlife Decline and Recovery in New England

Initially, it is helpful to examine reintroduction in New England within the broader context of wildlife depletion resulting from man's actions. When Europeans first settled New England, the region was almost entirely contiguous forest. Clearing and burning to establish farmsteads resulted in large-scale conversion of virgin forests into croplands and pasture. By the mid-1800s, about 70 percent of the original New England forest had been removed (Glass 1974). Obviously, this habitat change, as well as uncontrolled harvesting, and even persecution of some species, had a deleterious effect on many wildlife species (Allen 1942).

Other human actions contributed to habitat loss causing severe reduction of other wildlife populations. Pollution and dam construction resulted in the loss of the Atlantic salmon (*Salmo salar*) over most of New England. Habitat deterioration, persecution and, later, pesticides eliminated or severely diminished the populations of several species of raptors including the bald eagle, osprey (*Pandion haliaetus*) and peregrine falcon (*Falco peregrinus*).

With other regions of the nation enjoying a competitive advantage and the advent of many technological advances in agriculture that were better adapted to the West, area in farmland in New England began to decline in the 1800s. As abandoned farmland reverted to forest through natural vegetative succession, forest land became the primary land use and, once again, provided suitable habitat for many species of woodland wildlife that had diminished previously. In 1987, an estimated 81 percent of the New England region was forested (Haynes 1989), despite more recent pressures brought about by industrialization and urbanization.

With suitable habitat once again available and legal protection provided, many species that had been extirpated or reduced to low numbers began re-establishing themselves. Other species either have not re-established themselves naturally or are not repopulating as rapidly as desired, so publicly-financed reintroduction programs have provided assistance.

Although the bald eagle and wild turkey were devastated by man's activities, they have benefited from major re-establishment efforts, although for somewhat different purposes. The bald eagle was declared the national symbol in 1782 and developed considerable recognition and support on that basis alone. Conversely, support for the restoration of the wild turkey was based primarily on the desire to establish a huntable population.

Early decimation of the bald eagle resulted from both habitat deterioration and persecution. Although not abundant in New England, the bald eagle population was dwindling even before it was devasted by insecticide use, most notably dichloro diphenyl-trichloroethane (DDT), during the 1950s and 1960s. The pesticides tended to accumulate in the fatty tissues of the eagles and inhibited calcium release during eggshell formation, resulting in thin-shelled eggs that broke during incubation. In 1978, the U.S. Department of the Interior classified the bald eagle as "endangered" in 43 states, including each of the New England states (Engel and Isaacs 1982).

Restoration efforts for the bald eagle began with the placement of eagle eggs originating in Minnesota into nests of eagles in Maine, essentially the last New England state with a resident (although declining) eagle population. While these initial efforts had limited success, re-establishment efforts were initiated in nearby states. In New York, nestling eagles still unable to fly were imported from the Lake States and placed in hack towers (Nye 1983). The young eagles were released when able to fly. Success in terms of birds returning and ultimately nesting has been good. Restoration efforts within New England have concentrated primarily in Massachusetts and Maine, the latter relying on enhancement of its resident population. The costs, however, are high: the New York State Department of Environmental Conservation, for example, estimates their eagle restoration program has cost $500,000. Due to high costs and other factors, the remaining New England states hope to benefit from colonization from re-established populations in nearby states, but have no programs of their own.

Largely, the bald eagle restoration efforts in the Northeast have been quite successful and are within reach of recovery goals set for them (Nickerson 1988). As a result, no further reintroduction efforts are underway. It is believed that the populations established by the program will continue to expand until they reach the limits of available habitats.

Historically, eastern wild turkey were abundant in each of the New England states, including the southern portions of Maine, New Hampshire and Vermont (Nenno 1980). Massive land-use changes reduced habitat quality to the extent that wild turkeys were eliminated throughout the entire region by 1900.

During the time since wild turkeys were extirpated in the New England region, numerous attempts have been made to establish viable populations by stocking game-farm raised turkeys (Cardoza 1983). Although quite costly, these attempts have been largely unsuccessful.

While wild turkeys no longer existed in the New England area, remnants of the former population persisted in south-central Pennsylvania. This population began to expand in the early 1940s, and later in the decade wild turkeys were re-established in southwestern New York (Nenno 1980). From this naturally-expanding population, a trap-and-transfer program eventually was established that enabled the restoration of wild turkeys throughout most of the suitable range in New York and New England. In some states, wild turkeys now exist in areas beyond their original range.

The success of the wild turkey trap-and-transfer program has been phenomenal. After years of frustration in establishing viable, self-sustaining populations by using gamefarm turkeys, relatively small plantings of trapped wild turkeys have resulted in population explosions. For example, an initial stocking of 31 wild turkeys, which had been livetrapped in New York and transferred to Vermont in 1969 and 1970, resulted, by 1973, in an estimated population of 500–600 wild turkeys in Vermont (Wallin 1977). The Vermont Fish and Wildlife Department records indicate the total cost over this five-year period was less than $75,000. By 1979, the Vermont wild turkey population was estimated at 8,000 (Bailey 1980). Moreover, this initial stocking has also resulted in wild turkey populations being established in Washington and Rensselaer counties, New York, and northern Massachusetts. Currently, wild turkey populations have increased to the extent that each of the New England states permits hunting.

Although wild turkeys likely would have expanded their range without a trap-and-transfer program, it would have taken much longer. Pennsylvania studies indicate that wild turkeys expand their range naturally at a rate of about five miles (8 km) or less per year (Wunz 1973). Natural and man-made barriers, however, could seriously impede such natural programs.

Political Actions Supporting Reintroduction

Public concern for restoration of depleted or extirpated species such as the bald eagle and wild turkey was manifested through political action rather than justified through any analysis of traditional measures of economic efficiency. Until quite recently, little effort has been made to justify wildlife enhancement through valuing extramarket payoffs to nonusers of the resource.

As the national symbol, the bald eagle's plight was well publicized. The Bald Eagle Act of 1940 placed the species under federal protection. Although not directed specifically at the bald eagle, banning the use of DDT in 1972 permitted gradual environmental recovery to the extent that several endangered species of raptors could again reproduce naturally. The passage of the Endangered Species Act in 1973, and subsequent amendments, gave the bald eagle further protection. Individual states also passed laws protecting bald eagles and other raptors (D'loughly 1988). Massachusetts and Maine enacted publicly-financed eagle restoration efforts. The decision to carry forth these reintroduction programs was based on political sentiment rather than any rigorous economic efficiency analysis.

With the wild turkey, re-establishment pressures appeared to have a quite different origin from those for the bald eagle. The wild turkey was a prized game bird, and considerable effort has been expended to repopulate the species in New England. The Endangered Species Act was not a factor since successful trap and transfer programs had already occurred in New England by the time it was enacted. State fish and game departments received cooperative funding for wild turkey restoration through the Pittman-Robinson Act. The National Wild Turkey Federation, as well as other organizations, provided substantial support for re-establishment efforts. While the trap-and-transfer procedure was highly effective and relatively inexpensive, it did represent a payoff to a substantial body of research that enhanced the overall program. Instrumental in the effort was the Northeastern Wild Turkey Committee of The Wildlife Society, an organization of wildlife management professionals, which provided technical information on habitat suitability and other considerations needed to make the program successful (Nenno 1980).

It appears that political action will continue to be the primary basis for judging the merits of future wildlife programs; while this may seem an anathema to some, it may be appropriate for controversies such as that involving the spotted own (*Strix occidentalis*) in the Pacific Northwest, to air conflicting views through the political system. At the same time, however, economic analysis is likely to play a much more important role in the future, especially where it can help broaden the context of valuation in a situation where budgets are tight and programs must compete for scarce funding. In this sense, we expect that economic analysis increasingly will be used to support political decisions, so it is important to understand the broader components of value as they relate to both socioeconomic and political concerns.

Methods

Information on public attitudes and extramarket values for the bald eagle and wild turkey was collected through a mail survey of 1,497 randomly selected New England residents drawn from telephone lists during winter 1989. A postcard reminder was mailed one week later. Two weeks after the postcard mailings, a follow-up letter urging participation was mailed with a second questionnaire. The questionnaire solicited information on attitudes about particular wildlife species, the monetary value placed on the existence of these species and the motivations underlying these values. Contingent valuation was used to estimate the amount of money individuals would spend to assure the continued existence of a given species. Those refusing to contribute were asked their reasons.

To collect the desired data for several species with a reasonably concise survey instrument, five different questionnaires were developed, only one of which was sent to each individual selected. The questionnaires were identical except for three questions directed at individual species. The three questions that were differentiated by species dealt with (1) knowledge of existence of the species in New England, (2) willingness to pay to preserve the species and (3) motivations underlying this willingness to pay. The two questionnaires pertinent to this study involved the bald eagle and the wild turkey.

Of the 1,497 questionnaires mailed, 237 were not deliverable. A total of 472 questionnaires was returned, a response rate of 37.5 percent. Twenty were not usable, so the number of valid responses was 452. There were 192 responses dealing specifically with the bald eagle (88) and the wild turkey (104). The remaining responses dealt with other species or combinations of species.

Results

Approximately 75 percent of the respondents were aware of the existence of both the bald eagle and wild turkey in New England. Only 28 percent, however, had ever seen a bald eagle in the wild in New England, and only 25 percent had seen a wild turkey in the region.

Despite limited contact, the existence of the species was viewed as quite important (Table 1); 53 percent indicated the existence of the bald eagle in New England was very important and 41 percent felt the existence of the wild turkey was very important. In fact, 89 percent attached some importance to the existence of the bald eagle in New England; 82 percent had a similar view for the wild turkey.

When asked why the bald eagle was important to them, 80 percent of the responses were classified as existence values (Table 2). Among the underlying motivations of existence values, intrinsic value was most frequently cited. Both bequest values and altruism were cited more frequently than concern for current or future use. Unfortunately, similar information was not collected for the wild turkey.

While an individual's attitudes toward wildlife are an important consideration, the extent of commitment to the well-being of a given species provides even stronger evidence of support for that species. Extent of commitment can be measured in part through willingness to pay in monetary terms. When asked if they would be willing to commit some of their personal funds to support programs to maintain wildlife, assuming the elimination of public funding, 38 percent were willing to make such a commitment. However, the majority, 62 percent, would not make such a donation for a number of reasons.

The percentage of people who would commit themselves to an annual donation over a five-year period and the amount they were willing to give varied between the two species (Table 3). Forty-eight percent of the respondents to the bald eagle questionnaire indicated they would make an annual donation. The average willingness to pay for this group was $19.28. For the wild turkey, 30 percent of those responding made a financial commitment; the mean willingness to pay was $11.86.

The willingness-to-pay estimates are imposing (Table 4). When expanded to the New England population over 18 years of age, bald eagle and wild turkey protection and enhancement received total annual commitments of $69.6 million and $42.8 million, respectively. An overwhelming proportion of this willingness to pay for the protection and enhancement of wildlife was attributed to existence values as opposed to option values.

Motivations underlying commitment to contribute for the bald eagle and wild turkey also reflected concerns for the species' existence rather than any probable use on the part of respondents (Table 5). Even though the wild turkey has value as both

Table 1. Importance for existence of bald eagle and wild turkey in New England.

Importance	Bald eagle		Wild turkey	
	Respondents	Percentage	Respondents	Percentage
Very	238	53.2	185	41.4
Somwhat	159	35.6	181	40.5
Not very	24	5.4	62	13.9
Not very important at all	15	3.4	17	3.8
No answer	47	2.4	2	0.4
Totals	447	100.0	447	100.0

Table 2. Reasons why existence of bald eagle was important

Value	Percentage
Personal use	
Current use (observation)	3.2
Option value (chance for future observation)	8.8
Subtotal	12.0
Existence value	
Altruism	16.0
Bequest	23.0
Intrinsic	41.0
Subtotal	80.0
Not answered	8.0
Total	100

a game bird and for observation, only 6 percent specified option-value motivations. For the bald eagle, option value motivated 10.5 percent of donations. Intrinsic motivations for committing funds exceeded all other categories of giving for both the bald eagle and wild turkey. For each species, bequest values were the second most frequently cited motivation. Altruism accounted for 12.8 percent for the bald eagle as compared to 7.6 percent for the wild turkey.

While 62 percent of the total respondents indicated they would not commit themselves to any personal payments to specific wildlife protection funds, the reasons given for not participating do not suggest opposition to these programs (Table 6). Forty-four percent of the respondents to the bald eagle questionnaire indicated they would not make a donation because "money should come from taxes and license fees instead of donations." With respect to the wild turkey, 37 percent held this view. Others indicated (24 percent for the wild turkey, 22 percent for the bald eagle) the species was important to them, but refused to place a monetary value on it. A substantial proportion of the respondents indicated other reasons for not contributing. A small percentage of the returns indicated the wild turkey was of no value to the respondent, while no one claimed the bald eagle was of no value.

Discussion

The successful efforts to re-establish viable populations of bald eagles and wild turkeys in New England appear to have strong public support. Furthermore, the overwhelming proportion of the respondents in the case of the bald eagle (similar

Table 3. Amount of contribution per year (five-year period) to maintain bald eagle and wild turkey populations in New England.

	Willingness to pay					
	Would give		Would not give			
Species	Number	Percentage	Number	Percentage	Total amount	Mean willingness to pay
Bald eagle	38	48	41	52	$1,523.50	$19.28
Wild turkey	29	30	68	70	$1,150.00	$11.86

Table 4. Estimated option and existence values per year over five-year period for bald eagle and wild turkey in New England

Value	Inference to total New England population by species — Estimated value (millions of dollars)	
	Bald eagle	Wild turkey
Option	7.3	2.6
Existence	62.3	40.2
Total	69.6	42.8

data not collected for the wild turkey) indicated their reason for concern for the species related to other-than-current or future personal use. The highest percentage of respondents indicated a concern that the species had a right to exist on its own merits, regardless of its relationship to humans.

While these expressions of concern for re-establishment provide some measure of public support, they do not weigh the depth of such support. Measures of existence and option values are a better indication of public commitment to such programs. Overall, thirty-eight percent were willing to make a financial commitment to maintain and enhance wildlife populations. The primary reasons given by those not willing to make donations did not infer opposition to re-establishment programs, but questioned the appropriateness of contributions to finance them and the validity of monetary values for wildlife. Only a small proportion indicated the species were of no value to them.

The magnitude of extramarket values associated with the bald eagle and wild turkey are impressive. The estimated total New England annual commitment of funds for the bald eagle was $69.6 million and $42.8 million for the wild turkey. Almost 90 percent of this value was for existence values as opposed to option values for the bald eagle. In the case of the wild turkeys, a game species, the proportion of the total value for existence values was surprisingly higher than that for the bald eagle.

Motivations underlying these values again demonstrated great support for the existence of wildlife on its own merit. Respondents to both questionnaires listed intrinsic values most often as the underlying motivation for committing funds to the preservation of a wildlife species. Bequest values were the second most frequent answer given. Altruism, the least frequently given motivation for existence values, still exceeded option values in both cases.

These results should be interpreted with some caution. Willingness-to-pay assessments are hypothetical, so there is some uncertainty about the commitment of

Table 5. Motivations underlying donations for bald eagle and wild turkey protection in New England by percentage of respondents

	Percentage of donations					
		Existence value				
Species	Option value	Altruism	Bequest	Intrinsic	Total	Total
Bald eagle	10.5	12.8	30.1	46.7	89.6	100.0
Wild turkey	6.1	7.6	37.6	48.7	93.9	100.0

Table 6. Reason respondents would not contribute for bald eagle and wild turkey protection.

Reason for not contributing	Species: Bald eagle Number	Bald eagle Percentage	Wild turkey Number	Wild turkey Percentage
Money should come from taxes and license fees instead of donations	18	44.0	25	37.0
Species is not worth anything to me	0	0.0	4	6.0
Species is important but I refuse to place a dollar value on it	9	22.0	16	24.0
Other	14	34.0	23	33.0

respondents to follow through. Of course, this is a source of difficulty when the contingent valuation technique is used to collect data on extramarket values and there is considerable discussion of this matter in the literature.

Another concern is possible sample bias; some evidence suggests the respondents were more affluent and better educated than average for New England. If this is true, it could cause misleading inferences regarding the views of the general population. Nevertheless, the overwhelming magnitude of responses finding the selected wildlife species important, the substantial amount of funds that they were willing to donate and the reasons given for not donating (which tended to be favorable to wildlife), indicate tremendous public support even if it may be somewhat overestimated because of possible sample bias.

Traditional monetary measures reflect only a subset within the total valuation framework. By including extramarket values (existence and option values), we have expanded that portion of valuation that can be measured, but it still falls short of a total measure of value. Political actions continue to be the most significant means of gather support for programs and activities not effectively allocated through the market, but the measurement of existence and option values can add considerable support to the process.

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The Role of Hand-reared Mallards in Breeding Waterfowl Conservation

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Introduction

Waterfowl breeding in the mid-continent region of North America have undergone severe population declines during the last decade (U.S. Fish and Wildlife Service and Canadian Wildlife Service, 1989). A combination of drought and intensified land use is largely responsible for these declines (Nelson 1989). The overall duck population has also hovered near record lows since 1985.

This situation has led to unprecedented actions by private citizens and public officials to design and implement new programs to reverse the decline. Among the most notable of these is the North American Waterfowl Management Plan (NAWMP) which was signed by the governments of Canada and the U.S. in May 1986 (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1986). Since 1987, the proceedings of the North American Wildlife and Natural Resources Conference have heralded progress in implementing this ambitious plan. The most promising recent step by the U.S. government has been the signing of the North American Wetlands Conservation Act (S-804) by President George Bush on 13 December 1989, assuring significant financial support for implementation of the NAWMP across North America.

As with any threatened public resource, professionals and private citizens have responsibility to explore every avenue that might be of some positive and practical benefit in providing a brighter future for waterfowl. Among possibilities is the use of hand-reared mallards (*Anas platyrhynchos*) to enhance the size of breeding populations. This same possibility was seriously considered and studied during the last major decline of populations in the early 1960s. Burger (1975:106) noted that although waterfowl propagation has been viewed by most professionals as "a peripheral tool in waterfowl management the emphasis we humans place on peripheral solutions varies with the degree of the problem."

Our purpose in this paper is to analyze the information available on the use of hand-reared mallards in breeding population management and to evaluate the potentials of this practice in the context of modern-day waterfowl and wetland conservation. We examine the potential for assisting, with hand-reared mallards, remnant wild populations in a recovery, given that habitat programs envisioned in the NAWMP are implemented successfully. Given the widespread support for the NAWMP, among politicians, professionals and the general public, we assume the need for quality habitat is understood and paramount. Can mallard populations recover, simply in response to improved habitat conditions, or do they require some assistance, via hand-reared bird releases, to re-establish their original distributions and abundance?

Our focus will be on the use of "pure" wild-strain mallards (less than two generations removed from the wild) because it has long been understood that semi-domestic and game farm mallards have little potential for restoring breeding populations due to their low survival in the wild (e.g., Bednarik and Hansen 1965, Bailey 1979, Burger 1984). Our analysis also specifically and intentionally excludes consideration of information related to the value of birds raised and released locally in efforts to enhance nearby hunting opportunities.

Previous Studies

Most research on the potential of releasing hand-reared birds to enhance waterfowl management programs have used game farm or semi-domestic mallards (e.g., Bednarik and Hansen 1965, Burger 1975). However, several aspects of survival and breeding success of released wild-strain mallards were studied in Manitoba by Brakhage (1953), Sellers (1973), Bailey (1979), Gatti (1981) and, in North Dakota, by Lee and Kruse (1973).

Brakhage (1953) compared patterns of migration and mortality between 6,623 hand-reared birds [including mallards, pintails (*Anas acuta*), redheads (*Aythya americana*), and canvasbacks (*Aythya valisineria*)] and 6,284 wild-trapped birds of the same four species over a 21-year period (1932–51) on the Delta Marsh, Manitoba. Hand-reared and wild-trapped mallards comprised 2,007 and 2,930 individuals, respectively. These comparisons were not well controlled as there was considerable variation in release techniques, age at release, numbers released each year and sex and age of birds banded each year. Nevertheless, the results provided the first indication that hand-reared birds of wild genetic stock migrated in a similar pattern to wild-trapped waterfowl and had a similar tendency to home back to the area from which they were released.

However, hand-reared birds were dramatically more vulnerable to hunting mortality, resulting in few birds returning the following spring to breed. Based on his analyses, Brakhage (1953:476) concluded that "the release of ducks hand-reared from wild eggs cannot be recommended as a practical management technique."

Sellers (1973) reported on the largest, best controlled and most intensively studied release of hand-reared wild mallards. In 1969 and 1970, 1,474 female ducklings between four and five weeks of age were released in a 4-square-mile (10.36/km^2) study area in the Canadian prairie pothole region near Minnedosa, Manitoba. This represented a minimum of 15 times more mallard ducklings than could have been produced by the mallard pair population originally present on the study area during the same years (Sellers' data: 16 pairs per square mile (6.18/km^2), 20 percent nest success and fledged brood size of 6.7 with a 50:50 sex ratio). Sellers estimated the return of released birds to the study area to be between 20 and 25 percent.

The release area mallard breeding population was elevated to 50 and 66 paris per square mile (19.3 and 24.5/km^2) in 1970 and 71, respectively. During the two years following release, the proportion of all mallards in the experimental area producing broods was only between 9 and 12 percent despite better than average habitat conditions for breeding waterfowl. Thus, while Sellers confirmed the ability of wild stock mallards to migrate and return to areas from which they were released, serious doubt was cast on the ability of such birds to reproduce and sustain themselves once their populations had been artifically elevated.

Sellers (1973) concluded the decline of the mallard breeding population from 36 paris per square mile (13.9/km^2) in 1952 (Dzubin 1955) to 16 (6.18/km^2) in 1969 and 1970 was a result of low nesting success which, in turn, indicated excessive predation. It was evident that if nesting success was not improved, populations in the release area would quickly return to the original densities more characteristic of the region. This was indeed the case. MacFarlane (1977), working on the release area in a subsequent study, estimated the mallard population had declined to 14.4 pairs per square mile (5.2/km^2) by 1974, less than 25 percent of the number recorded three years earlier even though, during the six-year interval of those two studies, hunting also had been excluded.

Bailey (1979) followed Sellers with releases, in 1970 and 1971, of 1,204 female and 214 male hand-reared wild stock mallards on the Delta Marsh. He proposed to test if breeding populations could be elevated on large marsh habitat. He observed high pre-fledging mortality. However, for those birds surviving, he observed homing rates of 26–28 percent by yearlings and 53 percent by two-year olds. On two study areas over the two years of analysis, Bailey (1979) estimated that only, 0, 0, 10.5, and 14.8 percent of the hand-reared mallards produced broods. He also observed considerable year-to-year variation in the size of the native population using the Delta Marsh area because of movements to and from other areas on the breeding grounds. Bailey (1979:61) concluded that "In view of the poor reproductive success of hand-reared birds and the apparently high potential for natural immigration and production, mallard stocking is of questionable value on the Delta Marsh."

The emphasis of hand-reared mallard studies next switched to developing release techniques designed to increase survival of young to fledging and through the post-fledging period (Lee and Kruse 1973, Gatti 1981). Both of these studies showed that survival could be markedly improved by using a technique known as "gentle release." Neither study presented data on the comparative reproductive success of wild and hand-reared birds during subsequent years.

Interestingly, Lee and Kruse (1973) observed a 79-percent increase in breeding pairs and a 93-percent increase of young produced on their study area during the year immediately following release. They cautioned these increases were only partly the result of the releases, as habitat management on the study area had improved conditions. Nevertheless, one year later the population decreased by 47 percent and numbers of young produced decreased by 58 percent, both to lower levels than had been observed prior to the releases. This sudden change was attributed to poor habitat conditions resulting from drought.

These studies have allowed the development of techniques to maximize survival of released mallards, at least to fledging. Data are not available to evaluate survival to the following spring and homing rates compared to wild birds. Where data are available, there is a consistent pattern showing that surviving hand-reared birds experience markedly lower breeding success than their wild counterparts. No studies were discovered that demonstrated an improvement over time in the reproductive success of hand-reared hens. On both the Minnedosa and North Dakota release areas, breeding population improvements were short-lived after being artifically elevated by hand-reared mallard releases.

It is certain that wild and hand-reared mallards are subjected to identical factors affecting reproductive success and survival. Hand-reared birds have been shown, in every recruitment and survival parameter measured, to be inferior to wild birds.

Thus, we see little evidence that use of hand-reared birds has much hope to reverse the decline of North American mallards, especially where even natural populations cannot sustain their levels.

Rationalization for Using Hand-reared Mallards During the 1990s

It is dangerous to conclude that previously established generalizations always, or never, apply to every situation. Thus, to insure this previously discarded practice is not overlook inappropriately, we have reviewed the potential role of hand-reared birds in rebuilding mallard breeding populations. We constructed the following scenario to guide our assessment.

Mallard numbers are near record low levels in the prairie pothole region where 44 percent of the surveyed population breeds (Batt et al. 1989). Since many species of prairie ducks are known to home back to the area from which they were produced (Sowls 1955), we speculated that, during recent years, there may not have been enough birds available to occupy newly created or improved breeding habitat. When the NAWMP becomes fully implemented, along with the large acreages of retired cropland. there might be vastly more habitat than birds. A lack of birds might be expected to somehow limit the rate of population recovery.

Hand-reared birds could be released into these areas to help "kick start" the recovery of wild mallard populations. Implicit in this scenario is (1) the hypothesis that mallard hens have such strong homing requirements that populations are not able to respond to the availability of improved habitat in areas apart from traditional nesting areas (Hypothesis Ia), and (2) that the rate of population growth can be helped significantly with released birds (Hypothesis Ib).

Second, the Canada goose (*Branta canadensis*) has been successfully reintroduced, using hand-reared birds, into essentially all of its former range in North America (e.g., Cooper 1978, Johnson 1983, Lee et al. 1984) and has been introduced into other parts of the world outside its former range (e.g., Owen 1977). These successes may provide guidance for using hand-reared mallards to bolster existing populations in portions of this species' range. To test this possibility, we examined the hypothesis that mallards and Canada geese are similar enough in the critical aspects of their natural history that introductions and reintroductions of geese are functionally equivalent to adding hand-reared mallards to existing wild populations (Hypothesis II).

Discussion

Hypothesis Ia. If mallards, in fact, have a limited ability to pioneer into new areas, we would not expect to see large annual shifts in populations in response to presence or absence of good breeding habitat. The opposite has been observed ever since systematic surveys have been conducted. These patterns of movement into and out of the prairies in response to habitat quality has, perhaps most eloquently, been characterized in the writings of Lynch (1984).

Johnson and Grier (1988) conducted a comprehensive analysis of the relationship of mallard breeding population density to the 50 U.S. Fish and Wildlife Service (USFWS) May survey strata (Martin et al. 1979). They concluded that mallards do have a tendency to home to natal breeding areas, but they also opportunistically settle in improved and newly created habitats. Mallards are known to exhibit flexibility in drought years on the prairies when an increased proportion of the population settles in the northern strata. Clearly populations of mallards are not prevented, on a continental scale, from discovering and shifting into regions where good habitat has been created.

Data from local breeding waterfowl studies on the prairies have also shown consistent positive correlations between numbers of breeding mallards and spring ponds (e.g., Crissey 1969, Dzubin 1969). Krapu et al. (1983) concluded that variation in breeding habitat conditions, modified by previous year's recruitment and known homing rates, accounted for most of the variability observed in breeding densities on specific study sties. Lokemoen et al. (1990) showed that unsuccessful and yearling mallards hens were less likely to return the following year than were successful and older birds, indicating that settling patterns are influenced by breeding success during the previous year. Prairie waterfowl are thus capable of moving between regions of the breeding landscape in response to annual variations in habitat quality and past experience.

To our knowledge, no one has documented a situation where mallard numbers on specific sites were limited by the availability of surviving, locally-produced birds. However, there are numerous case histories of dramatic increases in populations as a result of local improvements in habitat quality that could only be accounted for by rapid pioneering of birds into new habitat.

Duebbert and Lokemoen (1980) demonstrated that dabbling duck nest densities as high as 631/100 ha (2.5 per acre) and nest success rates as high as 96 percent could be achieved in intensively managed nesting habitat in association with a high quality wetland base where mammalian predators had also been removed. Mallard pair densities increased from 23/8.3 km^2 (7.2 per square mile) in the first year of study to 90, 59, and 137 respectively, for the next three years during which predators were controlled. During these four years, mallard nest success was sustained at high levels, of 79, 99, 95, and 90 percent respectively. They concluded their study illustrated a basic concept of wildlife management regarding the inherent rate of increase that can be accomplished in waterfowl populations when inhibiting factors are removed.

Lokemoen et al. (1987) compared nest density and success between, (1) pairings (five in the first year, seven in year two) of controls to treated peninsulas on which electrical predator barrier fences (Lokemoen et al. 1982) were constructed and mammalian predators were removed and (2) pairings whereby predators were removed from nine islands in North Dakota wetlands one year after two years of baseline nesting data had been collected.

After two years, treated peninsulas had 280 nests, with 60 percent nest success and 1,546 young birds produced. Control peninsulas had only 39 nests of which 8 percent were successful and 29 young ducks were produced. On the islands, 52 nests were found during the two breeding seasons before predators were removed. Nest success was only 8 percent. The year after predators were removed, 851 nests were found of which 87 percent hatched.

Numerous other studies have shown phenomenal concentrations of breeding waterfowl on small patches of habitat where nest success was high (e.g., Duebbert et al. 1983). Clearly, there is strong evidence that waterfowl have great potential to occupy and reproduce in habitat where limiting factors have been removed or reduced.

Hypothesis Ib. Even though mallard breeding populations are currently depressed, in the surveyed areas alone the USFWS estimates populations of about 6.5 million breeding birds. Growth in mallard numbers each year will be predicated on two factors, size of the spring population and rate of increase achieved for that population.

In banking terms, these are analogous to size of the principal and rate of interest. Releasing hand-reared birds into wild populations is an effort to increase the size of the principal, i.e., "kick start" the population. As the studies reviewed indicate, this segment of the population will earn a lower rate of interest because released birds exhibit reproductive and survival rates inferior to wild mallards.

With rates of increase that have been achieved with improvements to habitat quality and a common understanding of the impact of favorable interest rates (i.e., population growth rate) on growth of investments (i.e., mallard numbers), we hypothesized the most cost-effective strategy to increasing mallard populations would be to improve recruitment rates. A simple model was constructed to test this idea. We used an estimate of population change (C) cited by Cowardin and Johnson (1979) as an index of recruitment rate (R). For our purposes, we held S (adult hen annual survival rate) and S_b (yearling hen survival rate from fall to spring) constant in the following formula:

$$C = S + RS_b, \text{ where at zero population growth, } C = 1.0.$$

An initial mallard breeding population of 6.5 million birds was used and the population was allowed to grow over 15 years at some constant rate.

Comparisons were then made between two basic methods of increasing population size. First, population growth rates, as an index to R, were increased to simulate improvements in habitat. Second, the recruitment rate was held constant, and different numbers of birds were released into the population. We assumed that once released birds survived to the following spring, they would survive and reproduce no differently than wild birds. This is an assumption we know to be liberal. Finally, we tried to simulate releases of birds into an improved habitat, comparing results to the scenario where only the habitat was improved.

Small changes in C can produce markedly different patterns of population change (Figure 1). A change in C from 0.95 to 1.05, probably within the range of normal variation, results in an population more than four times larger after 15 years. Thus, a small increase in recruitment rate can dramatically improve population status, even when survival rates are held constant.

When a population is declining ($C = 0.95$ in our example), a substantial number of birds must be released to simply stabilize the population. Assuming 25 percent of the released birds survive to the following spring, nearly 1.4 million mallards would have to be released annually to stabilize the population (Figure 2).

Releasing hand-reared birds into a wild population is expected to have little effect, whether the population is increasing or decreasing. Releasing 100,000 birds annually into a declining population ($C = 0.95$) for 15 years resulted in only 8 percent more birds than if no release had been undertaken, while the population had declined by 47 percent (Figure 2). Conversely, if the same number of birds was released into an increasing population ($C = 1.02$) little added benefit resulted. Releases accounted for only an additional 5 percent gain, but the population had gained 39 percent (Figure 3). Clearly, populations receive little boost by releasing mallards into habitat

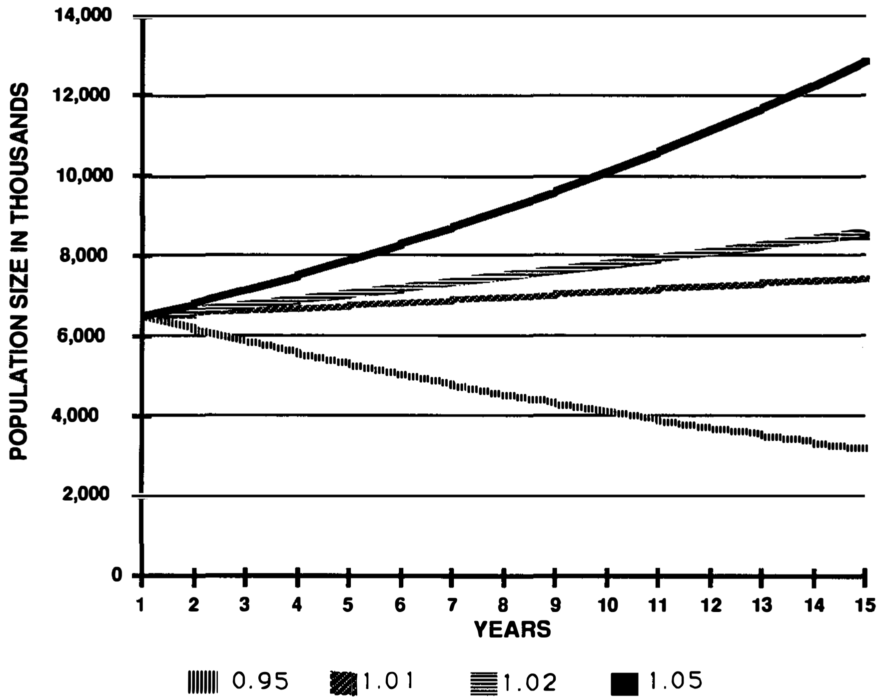

Figure 1. Predicted mallard population changes over 15 years resulting from four potential growth rates (C = 0.95, 1.01, 1.02 and 1.05).

where recruitment rates have already been improved. The cost of adding enough hand-reared wild-strain birds to noticeably improve continental populations, even relative to today's low population, would undoubtedly be much higher than taking the approach of habitat improvement in an effort to bolster rates of population growth for existing wild birds.

Hypothesis II. There are significant differences between the natural history traits of Canada geese and mallards, which explain why reintroductions, or establishing new populations of geese, are entirely different than enhancing existing populations of mallards with released birds. Canada goose release programs consist, fundamentally, of placing birds into good habitat where entire populations were extirpated following settlement (Stewart 1975). Because of the more precise homing patterns of geese, new flocks are prevented from discovering these areas to re-establish breeding traditions.

Goose programs are clearly rationalized on the availability of suitability empty habitat. In fact, prairie habitats may be more compatible for geese today than during prehistoric times and the early days of settlement. Today there are few predators large enough to challenge adult geese on nests or when they are tending their young.

Spilled agricultural grains are now readily available throughout the continent as are fertilized crops, lawns and golf courses, all resources which geese readily exploit.

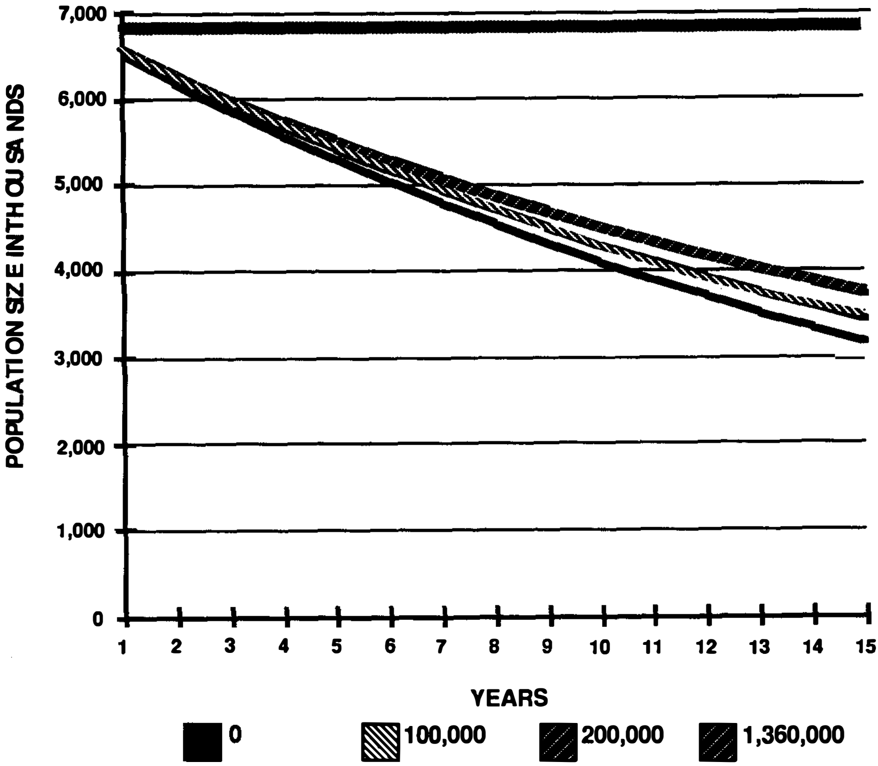

Figure 2. Predicted mallard population changes when growth rate = 0.95 and hand-reared birds are released into the population at three levels (100,000, 200,000 and 1,360,000/year) for 15 years.

Given some protection from hunting during the early years of population establishment, Canada goose populations can explode, and many case histories show that they can quickly become a nuisance.

Releases of mallards into habitats that already have native breeding populations that are below historical levels represent a different situation. Quite plainly, these habitats are underpopulated because mortality is out of balance with recruitment which is currently inadequate to sustain, or allow growth, of populations. It is obvious that, without correcting the problems that caused the habitat to be underpopulated in the first place, little can be gained by releasing inferior, hand-reared birds to supplement wild populations. In terms of banking, if the best investments (wild birds) are earning 0 percent interest, adding more principal (hand-reared birds) with an even poorer return than the original investment would not be an advisable strategy. The more appropriate approach would be to improve the rate of return through investments in habitat. Throughout the prairie pothole breeding range, the great bulk of evidence collected over the last 30 years of research supports the view that recruitment is the single most important limiting factor (e.g., Nelson 1989).

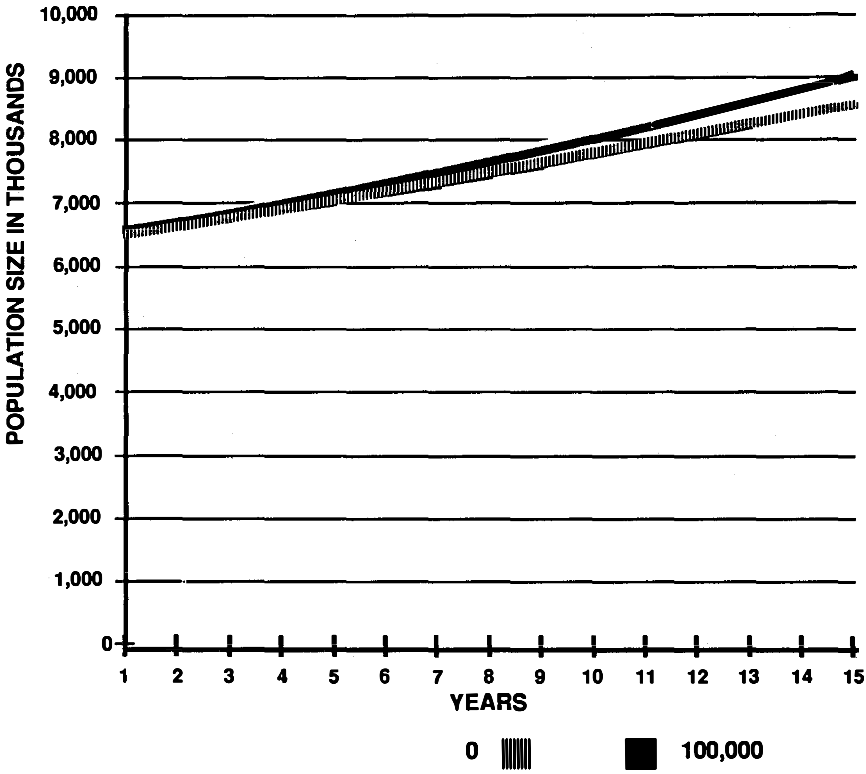

Figure 3. Predicted mallard population changes when growth rate = 1.02 and 100,000 hand-reared birds are released each year for 15 years.

Conclusions

The use of hand-reared wild-strain mallards to restore breeding populations is not supported by the published literature. Studies have demonstrated inferior survival and reproductive capabilities of such birds released into the same environment that is incapable of maintaining wild populations. Clearly, the factors that caused these declines will even more relentlessly decimate the hand-reared stock.

Wild mallards have demonstrated considerable flexibility in responding to changing habitat quality on continental, regional and local areas. Numerous case histories indicate that wild birds rapidly can discover and exploit improved habitat and that the recovery of wild populations is limited by habitat quality, not availability of breeding stock.

Successes enjoyed by previous Canada goose restoration efforts do not rationalize the use of hand-reared mallards to accomplish the same goals because goose programs place birds into good habitat where the basic biology of the species precludes significant pioneering. This is not the case with most prairie breeding ducks, including mallards. Canada goose restoration successes do, however, provide compelling support for habitat restoration programs that can unleash the reproductive potential of wild birds. Geese have proven how quickly populations can grow when reproductive success and survival are high.

While current conditions in the core of the breeding range have depressed duck populations for an extraordinary period of time, there is no evidence to support the hypothesis that wild populations cannot recover when factors inhibiting recruitment are relaxed. Mallard populations have a tremendous capacity for growth when reproductive success is improved and can rapidly pioneer new habitats as they become available. The basic tenets of the NAWMP recognize this by focusing expenditures on programs that improve rates of recruitment, largely by raising nesting success, rather than expending funds on efforts to add hand-reared birds to an already troubled population.

We offer the further observation that only hand-reared mallards have ever shown any potential in these types of programs. The success of waterfowl conservation will be judged on the recovery on the complete community of ducks and other wildlife that depend on healthy upland and wetland habitats. Hand-reared birds offer little hope of contributing to breeding mallard population conservation and have no potential of contributing to the broader goals of waterfowl and wetlands conservation.

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Translocating Prairie Grouse: What Have We Learned?

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Introduction

The release of wild-trapped or pen-reared game birds to establish populations in unoccupied habitat is a common wildlife management practice. Of the upland game birds of North America, the prairie grouse—prairie-chickens (*Tympanuchus cupido pinnatus, T. c. attwateri, T. pallidicinctus*), sharp-tailed grouse (*T. phasianellus*) and sage grouse (*Centrocercus urophasianus*)—have the poorest record when it comes to establishing populations. It is no coincidence that relatively sedentary species such as wild turkeys (*Meleagris gallopavo*), ruffed grouse (*Bonasa umbellus*), ring-necked pheasants (*Phasianus colchicus*) and gray partridge (*Perdix perdix*) have been the easiest to establish. In contrast, prairie grouse are mobile and make extensive seasonal movements, primarily by flying. This mobility makes it difficult to keep these birds in the vicinity of the release site. Lewis (1961) indicated that minimal movement away from release sites is the key to a successful translocation. Attempts to establish prairie grouse have been numerous but not well documented, and few results have been published. This paper summarizes information from the literature, unpublished progress reports and discussions with individuals involved with prairie grouse translocations.

Historical Review

Pre-1940. The earliest efforts occurred during the mid- to late 1800s, when large numbers of greater prairie-chickens were transplanted from the Midwest to the East Coast in unsuccessful attempts to re-establish heath hen (*T. c. cupido*) populations (Gross 1928, Phillips 1928). Numerous unsuccessful attempts involving large numbers of birds were also made during this period to establish sharp-tailed grouse on the East Coast and in New Zealand, and prairie-chickens in California, Washington, Hawaii and New Zealand; thousands of prairie-chickens were shipped to England and Europe in hopes of establishing the bird there (Phillips 1982).

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1940–1970. In the 1940s, 1950s and 1960s the continued decline in numbers and distribution of prairie grouse (Hamerstrom and Hamerstrom 1961, Christisen 1969), resulted in renewed efforts to supplement or re-establish populations. During this period prairie-chickens were translocated in Illinois, Missouri, South Dakota, Wyoming, Texas and Oklahoma (Kruse 1973). Most of these efforts involved less than 75 birds and met with little or no success.

Oklahoma translocated over 1,000 greater prairie-chickens between 1956 and 1967. The largest releases, 314 birds in 4 years (Jacobs 1959), appeared to be successful as indicated by the presence of nests, broods and active booming grounds. However, Kruse (1973) reported most of these populations had disappeared by the early 1970s. Jacobs (1959) believed the lack of success was due to dispersal of birds away from release sites.

Most translocations of sharp-tailed grouse during this period involved large numbers of winter-trapped birds and were generally attempts to supplement declining populations in the Lake States rather than re-establish populations. Returns and recoveries from banded birds in these studies indicated that translocated sharptails made large wandering movements while dispersing away from release sites (Hamerstrom and Hamerstrom 1951, Ammann 1957).

The most successful efforts occurred where sharp-tailed grouse were established on two islands in Lake Michigan by translocating birds during winters 1939–41. Ammann (1957) believed the success of these efforts was due to restricted dispersal caused by insular conditions, which discouraged the bird's innate tendency to wander and disperse in all directions.

There have been few attempts to re-establish lesser prairie chickens. A few were unsuccessfully translocated in Colorado in 1962 (Kruse 1973), and a few were apparently established on Niihau in the Hawaiian Islands around 1934 (Schwartz and Schwartz 1949). The present status of this population in unknown, and details on its establishment are sketchy.

Sage grouse were unsuccessfully translocated during this period in Oregon (Batterson and Morse 1948), New Mexico, British Columbia (Hamerstrom and Hamerstrom 1961), and Montana (Martin and Pyrah 1971). The largest effort was in Wyoming where Patterson (1952) translocated over 5,000 sage grouse that were feeding in alfalfa fields during summer. Many adults which were moved 20–40 miles (32–64 km) returned to the area of capture. Patterson concluded that translocating adult sage grouse to re-establish or supplement populations would not work because adults dispersed quickly from release sites.

Because of these early efforts, the concept evolved that large numbers of prairie grouse had to be released to get enough birds to stay and establish a population. Large numbers of prairie grouse, however, are not readily available or are difficult to catch when populations are declining.

1970–1990. As prairie grouse numbers and distributions declined through the 1970s and 1980s (Miller and Graul 1980, Westemeier 1980) attempts to re-establish prairie grouse continued with limited success. Personnel from Illinois, Wisconsin, Minnesota, North and South Dakota, Iowa, Texas, Colorado and two national wildlife refuges, one each in Nebraska and North Dakota, attempted to re-establish prairie-chickens. Interest in establishing sharptails also increased, and attempts were made in Minnesota, Kansas, South Dakota, Pennsylvania, Idaho and Montana. Idaho is the only state that has seriously attempted to re-establish sage grouse. In making these attempts, many different approaches have been tried with varying success.

Release Methodology

Pen-reared birds. Kruse (1973) recommended that large numbers of pen-reared prairie-chickens be released to overcome the problem of dispersal from the release area. However, relatively few sage grouse and sharptails have been reared in captivity, and only then at considerable expense.

An attempt to re-establish prairie-chickens in Minnesota in 1980–82 was made by gently releasing 94 pen-reared birds from a holding pen in September (35 in 1980, 24 in 1981, 35 in 1982). Evaluation was limited, but a spring survey revealed only one bird in 1983.

The largest group of pen-reared greater prairie-chickens (n = 804) was produced by the U.S. Fish and Wildlife Service (Kruse 1984), 456 of which were made available to Wisconsin for release. About half of these were "gently released" over a two-year period from a holding pen at Crex Meadows Wildlife Area in northwestern Wisconsin during October and April, 1974–76.

The releases at Crex Meadows were closely monitored using radio telemetry (Toepfer 1988). In contrast to translocated wild birds, all pen-reared birds remained within 1.2 miles (2 km) of the release pen. Daily movements were limited and similar to those of wild birds in the summer. Pen-reared birds were nine times more observable than wild prairie-chickens, but also attracted raptors at a rate of four times greater than for wild prairie-chickens. None of 55 radio-marked pen-reared birds survived beyond 120 days; 90 percent were dead within 31 days. Mean survival time was 14.3 days, and annual survival was 0.5 percent. Predators were responsible for 80 percent of the losses. Ten nests were found, only one hatched and none of the pen-reared hens fledged chicks.

The limited movements and poor survival of pen-reared prairie-chickens were comparable to those reported in other studies of pen-reared birds (Hessler et al. 1970, Roseberry et al. 1987). These researchers attributed the high mortality to the "naiveness" of pen-reared birds which made them easy prey for predators. Toepfer (1988), however, found that selection inside the pen favored individuals that flew poorly or not at all. Behavioral comparisons with wild prairie-chickens indicated that pen-reared birds were capable of differentiating predators from non-predators (Toepfer 1988). However, because of pen-conditioning, they responded by running rather than taking flight like wild birds. The flushing and flight distances of pen-reared birds were half those of wild birds. Weights and breast circumferences of pen-reared birds were significantly less than those of wild birds and varied directly with the condition of flight feathers and their ability to fly. Consequently, pen-reared birds have to make both behavioral and physiological adjustments when released into the wild.

Pen-held wild birds. Two releases have been made by temporarily holding wild prairie grouse in pens. In one unsuccessful effort in Illinois, prairie-chickens captured on display grounds were held in a pen for release during summer (Sparling 1979). The other occurred in Kansas, where over 500 sharptails were captured during winter in Nebraska, North Dakota and South Dakota over a seven-year period, 1982–88 (Rogers 1988). These birds were held in pens adjacent to the release site for one to three months and then released from boxes in the presence of decoys and recorded sounds of displaying male sharptails. Many cocks were attracted to and established territories on the artificial dancing ground. Limited monitoring in years following the releases revealed three dancing grounds with 25 cocks in 1988. However, information on establishment, movements and survival, especially of hens, is lacking.

The temporary holding of prairie grouse in pens may have greater potential for sharptails because they appear to adjust to pens more readily than prairie-chickens. The latter have to be wing clipped to reduce mortality and prevent injuries. Penning of wild birds is expensive and leads to weight loss and muscle atrophy due to a lack of flight exercise (Toepfer 1988).

Egg substitution. Eggs from pen-reared prairie-chickens were placed under incubating wild sharp-tailed grouse hens in an attempt to re-establish prairie-chickens at Arrowwood National Wildlife Refuge, North Dakota during 1988–89. This effort was monitored by personnel from Montana State University. No male prairie-chickens were observed in spring 1989, and none of the radio-marked sharptail hens that received prairie-chicken eggs was known to have fledged chicks (H. R. Burt pers. comm.).

Breeding season releases. Most attempts to re-establish prairie grouse during the past two decades have concentrated on translocating birds during the breeding season. Most of these efforts were poorly documented and provided limited information on establishment rates, survival, movements and behavior of translocated prairie grouse.

Intensive studies on translocated prairie-chickens were conducted in Wisconsin in the mid-1970s (Toepfer 1976, 1988). Initially, 7 wild-trapped prairie-chickens (three cocks, 4 hens) were radio-marked and moved to a new location. This study showed that movements of translocated prairie grouse even when released in apparently good, occupied habitat were characterized by orientation periods of 5–28 days during which time the birds made large, wandering movements away from release sites. These movements suggest search behavior for previous breeding territories/nesting areas which are established before mating (Toepfer 1988).

Resident prairie-chickens did not prevent translocated females from dispersing from release sites, but did appear to influence establishment of hens. Daily movements of translocated cocks after release were 2.5 times greater than those of radio-marked males. Daily movements of translocated hens were comparable to residents, but their home ranges were 1.6 times larger. All translocated hens nested and hatched clutches, and translocated cocks established territories on existing booming grounds. The translocated prairie-chickens became established within 0.5–3.5 miles (0.8–5.6 km) of release sites.

In 1976, 31 wild prairie-chickens (19 cocks, 12 hens) were released at Crex Meadows in Wisconsin in April along with 197 pen-reared birds. This population was supplemented with 20 wild hens in April and with 12 wild cocks during summer (Toepfer 1988). This study indicated different movement patterns and establishment rates for translocated cocks and hens. Fifteen of 19 wild cocks released in April established within 1 mile (1.6 km); 2 radio-marked cocks wandered 4.5–8.3 miles (7.2–13.4 km) from the release site for 9–27 days and then returned to the release area. The high establishment rate for wild cocks appeared to be due to their attraction to pen-reared cocks and hens being held for release; 9 of 12 cocks displayed at the pen and 15 of 19 were observed within 1 mile (1.6 km) of the pen.

Most released hens made extensive wandering movements away from the release site, and only 4 of 17 radio-marked hens established within 2 miles (3.2 km) of the release site. The remaining hens exhibited orientation periods of 8–55 days ($\bar{x}$ = 20.4) during which time they made extensive movements from the release site. The general pattern was to move through open agricultural areas surrounding Crex Meadows until they were preyed upon or "settled" and established new home ranges with regular movements patterns.

Daily movements of translocated hens averaged 2.6 miles (4.2 km) per day, nine times greater than those of resident hens during comparable periods. One hen moved 64 miles (103 km) in 3 days, and it was not uncommon for a hen to move 10 miles (16 km) a day for several consecutive days. Three hens moved 5–7.5 miles (8–12 km) from the release site, returned in 7–11 days, established territories, nested and fledged chicks. The presence of resident birds from the 1976 release did not prevent hens released in 1977 from leaving the area.

Eleven surviving hens established 3.6–35.2 miles (5.8–56.8 km, $\bar{x}$ = 22.3 km) from the release site. Five of these 11 nested and 3 laid abnormally small clutches of infertile eggs; only 3 produced broods. These large wandering movements exhibited by hens are costly in terms of condition and survival. Three hens recaptured by night-lighting during orientation lost 15–16.5 percent of their body weight in 17–24 days. Survival during orientation was 64.4 percent (78 percent for cocks, 59 percent for hens). Survival was higher for cocks because orientation periods were shorter and movements through unfamiliar areas much smaller. Survival for hens that left the release site was 33 percent. Annual survival of resident prairie chicken hens is 46 percent (Hamerstrom and Hamerstrom 1973).

The Crex Meadows reintroduction was initially successful as the population contained 20 unbanded cocks in 1981, 4 years after the last birds were released. By 1989, 12 years after the last birds were released, only two cocks remained. This decline may have been due to a 33 percent loss of grassland habitat to brush encroachment. This change in habitat appeared to favor sharptails, which increased from 14 to 81 cocks in 14 years.

Colorado personnel translocated 36 (16 cocks, 20 hens) and 40 (15 cocks, 25 hens) greater prairie-chickens in 1984 and 1985, respectively (Hoffman 1986), into an area where only 1 prairie-chicken was know to occur. Birds were released into an area where 3,700 acres (1,497 ha) of grassland habitat had been restored. Thirteen birds were radio-marked; contact was lost with 5, and 3 were killed. Most of the radio-marked birds dispersed considerable distance from the release site (x = 3.8 miles, 6.1 km). In 1985, 20 cocks were seen on 5 booming grounds. This population has maintained itself, and present population estimates are 100–200 birds (C. E. Braun pers. comm.).

Attempts were made to re-establish prairie-chickens in two areas in Iowa during the 1980s. The first in 1980 and 1982 consisted of 101 birds with 53 and 48 released during February 1980 and April 1982, respectively (Wooley 1985). Information form 11 radio-marked birds indicated that predation was high and that birds dispersed rapidly from the release site. Several birds moved 3.0–6.5 miles (4.8–10.5 km) from the release site, and one cock established 39.8 miles (64 km) away. In 1983, one booming ground with four birds was located 7 miles (11.3 km) from the release site. Movement patterns of radio-marked birds and subsequent sightings indicated the birds preferred more open bottomlands adjacent to savannah habitat where they were released. A second attempt at re-establishing prairie-chickens in Iowa occurred from 1986–1989, when 250 birds were released during the breeding season in the presence of tape recordings of displaying cocks. No birds were radio-marked, but most of these birds left the release site as only one display ground with 5–6 cocks was observed within 1 mile (1.6 km) of the release site. This dispersal may have been habitat related, as a booming ground of 7–8 birds developed in Missouri 9–10 miles (15.5–16 km) distant in habitat more similar to that of their point of origin (M. Moe pers. comm.).

Efforts to re-establish Columbian sharp-tailed grouse (*T. p. columbianus*) have been made in Idaho and Montana. The Idaho program in 1985 was unsuccessful, with radio-marked birds moving 10–15 miles (16–24 km) from the release site into Washington (J. Naderman pers. comm.). The Montana efforts were more supplemental than a re-establishment attempt, since a few resident birds were still associated with a small island of remaining habitat. However, some birds translocated from British Columbia did become established at the release site.

A sage grouse reintroduction project was attempted in Idaho by translocating birds during the breeding season. Eighty-nine (66 cocks, 23 hens) and 107 (65 cocks, 42 hens) birds were released in 1986 and 1987, respectively, in the Sawtooth Valley (Musil 1989). Forty-four birds (13 cocks, 31 hens) were radio-marked. Translocated sage grouse moved erratically from the release sites during the first 3–6 weeks. Mean and mean maximum distances from the release site were 3.3 (5.3 km) and 7.1 miles (11.4 km) for 10 hens, and 2 (3.2 km) and 5.4 miles (8.7 km) for 5 cocks. One radio-marked hen moved 22.7 miles (36.5 km) and returned after 10 days to within 1.9 miles (3 km) of her release site. Three small strutting grounds were established in 1987 and two in 1988.

Summer releases. In contrast to birds translocated at other times of the year, 10 radio-marked prairie-chickens in Wisconsin, recaptured by night-lighting and translocated in August during their molt, experienced higher survival from August to December (80 percent) than those translocated in the spring (33 percent). All remained within 2.5 miles (4 km) of the release sites and made daily movements comparable to resident birds (Toepfer 1976, 1988).

Fredrickson (1987) reported similar results for radio-marked prairie-chickens translocated during summer in South Dakota. All radio-marked birds remained within 2 miles (3.2 km) of the release site, and 12 of 29 translocated during August 1986 were observed in the release area the following May; the 4 radio-marked birds wintered from 6–26.7 miles (9.7–43 km) away. After three years of summer releases, a population developed with at least 25 displaying cocks.

Sharptails translocated during summer also remained near their release site. In 1989, 25 sharptails (14 cocks, 11 hens) were translocated during July and August from northwestern to southcentral Minnesota. After one month, 6 of 7 radio-marked birds were within 1 mile (1.6 km) of the release site, 5 were within 0.16 miles (250 m), and 16 of 25 were seen 20–40 days after release (J. E. Toepfer unpublished data).

Other known translocation efforts. An attempt was made to re-establish Columbian sharptails on the National Bison Range in Montana in 1980 by capturing and moving hens with young broods (Lockie et al. 1980). This effort was unsuccessful because the hens died enroute and the chicks were hand-reared and then released.

There has apparently been only one attempt to translocate prairie grouse during late fall and early winter. This effort occurred in Texas where Attwater's prairie chickens were captured during October and December and moved 150 miles (240 km) (Lawrence and Silvy 1987). This effort was unsuccessful as only 2 of 20 radio-marked birds established in the vicinity of the release site. These birds also moved from the release site dispersing up to 4.5 miles (7.3 km) with up to 75 percent mortality within five to six months.

A mixed approach was used at Crescent Lake National Wildlife Refuge in Nebraska where attempts were made to re-establish prairie-chickens by releasing 278 wild birds and placing 71 prairie-chicken eggs under incubating sharptail hens (Heisinger and Brennan 1987). Subsequent spring censuses found only one booming ground with 5 cocks in 1987, which was inactive by 1989. Several banded birds from this release were shot 35–60 mile (56–97 km) from the release site. This area has a healthy sharp-tailed grouse population.

Conclusions and Recommendations

Since 1950 there have been at least 52 attempts to establish prairie grouse populations, (greater prairie-chickens—26, sharptails—12, sage grouse—12, lesser prairie-chickens—2). Most failed or succeeded only in establishing small temporary populations. It is difficult to ascertain why each failed because many were not well-documented. The one primary reason for so many failures appears to be inadequate use of the available information on basic biology and ecology of the species in question. Notable deficiencies are suitable and necessary amount of habitat, species dispersal patterns, and documentation of results.

The two projects that have had the greatest success were those where over 3,500 acres (1,416 ha) of grassland habitat were recreated and managed for several years before prairie chickens were released. Thus, the amount of quality habitat is the ultimate factor that will determine whether a translocation effort will succeed or fail. Prairie grouse inhabit open areas that are in demand and frequently drastically altered by plowing, mowing or grazing. Most prairie grouse habitat used in reintroduction attempts has been actively restored or are isolated areas that have been maintained by management.

The first objective of a reintroduction program should be to establish enough suitable habitat to meet the year-round needs of 200 birds or 100 displaying cocks. Historical evidence indicates that once isolated prairie grouse populations fall below 100 cocks they will eventually disappear without habitat improvement or acquisition.

The minimum size necessary for successful reintroduction will vary with quality of habitat. However, size of a prairie grouse management area for 100–125 cocks can be approximated by using half the mean distance between active display grounds in a well-established population (Bergerud 1988). This area multiplied by 100 and divided by the mean number of cocks per display ground in the well-established population will give a reasonable estimate of the minimum size of a release area—

approximately 9.7 square miles (25 km^2) for prairie-chickens, 11.6 square miles (30 km^2) for sharptails and 19 square miles (50 km^2) for sage grouse. The amount of actual habitat—undisturbed grass for prairie chickens, undisturbed grass-shrub habitat for sharptails and sage brush (*Artemisia* spp.) for sage grouse—should make up as much of the area as possible, and no less than one-third for prairie-chickens and sharptails, and approximately two-thirds for sage grouse.

The habitat from which birds are taken should be matched with the release area. Toepfer (1988) found that moving birds from Minnesota into the less-open habitat of northwestern Wisconsin increased movements and dispersal from the release area.

Griffith et al. (1989), in a survey of over 700 recent translocations, also found that high-quality habitat was critical to a successful translocation. They also suggested that genetics of the translocation stock was important. Genetic variation and especially mixing of subspecies should be carefully considered when translocating small numbers of prairie grouse.

Disease has not been considered a problem when translocating prairie grouse, but with the interstate movement of birds it could be a serious factor. All translocated birds, especially pen-reared birds, should be examined for disease and parasites.

Pen-reared birds are much less mobile than wild birds, but they are costly, difficult to raise, and acquire behavioral and physical handicaps that make them susceptible to predators. Studholme (1948) and Griffith et al. (1989) indicated that wild-trapped animals are much more successful than captive-raised animals in re-establishing populations. If pen-reared prairie grouse are to be released, predator control should be conducted before and during the release; this practice is not necessary with wild prairie grouse. However, selective removal of trees that are used for hunting perches by raptors will limit their access to open areas (Toepfer 1988).

The development of efficient methods of trapping prairie-chickens and sharptails on display grounds (Toepfer et al. 1988) has made releases during the breeding season more attractive. However, because translocation during this time have a low establishment rate, release methodology must reduce dispersal and mortality of translocated birds or compensate for these losses by releasing more birds.

The recent successful establishment, within 2.5 miles (4 km) of release sites by sharptails and prairie-chickens translocated during summer in four release areas is encouraging in view of past failures. The rationale behind transplanting during summer is that birds are not sexually active, their mobility is reduced because they are molting, and survival is enhanced because food, cover and buffer prey species are abundant. Individuals are also able to adjust gradually to the new area as they complete their molt and increase movements in the fall.

There are two major advantages to translocating birds during the summer. A smaller number of adults is required because of increased survival and establishment, and birds are translocated after nesting and brood rearing, which makes it politically and biologically more acceptable when removing birds from limited populations.

The key to survival of translocated birds in unoccupied quality habitat is successful establishment of individuals, as extensive orientation movements represent responses of individuals, not groups, to being placed in an unfamiliar area. Thus, in a translocation venture, most principles of population dynamics are not operating, and the population will not be functional until the translocated individuals establish territories and reproduce.

Intraspecific behavior must be considered in a translocation effort. The presence of sharptails is likely to be a deterrent to establishment and maintenance of a prairie-chicken population. This conclusion is based on observations of the two species, where sharptails dominated prairie-chickens in feeding areas over 90 percent of the time (Toepfer 1988). This dominance was also reported by Sharp (1957). Ammann (1957) reported that, once sharptails became more abundant than prairie-chickens, the latter usually disappeared in five to six years. We know of at least 12 isolated areas that had populations of both species that are now inhabited by only sharptails. High densities of pheasants can also cause problems by parasitizing prairie grouse nests (Vance and Westemeier 1979). A difference of two to three days in incubation periods causes prairie-chicken hens to leave their nests prematurely when pheasant eggs hatch.

Another overlooked aspect of wildlife restoration projects is whether or not removal of individuals has negative effects on a population. This information will help agency personnel decide on whether or not they will provide birds for translocation projects. Toepfer (1988) reported that unhunted prairie-chicken populations are capable of compensating for removal of 35 and 50 percent of the hens and cocks, respectively, from a single booming ground.

The failure to document and thus learn from previous efforts is a hidden, but real cost of translocation projects and is documented by the continued use of unsuccessful procedures. Many failures that blame inadequate habitat may have been due to poor procedures or lack of knowledge about the animal and its needs. Although documentation is expensive and time-consuming, it is an indispensable part of a translocation effort. Documentation of release methodology, movements, habitat use, and survival should be obtained for each release until we develop the knowledge necessary to consistently re-establish prairie grouse populations.

Lastly, agencies should be cautious about declaring a project a success. Leopold (1933) stated that success or failure cannot be determined until the addition of birds has stopped for at least three years. The re-established population at Crex Meadows remained at two to four cocks for nine years. Prematurely declaring a translocation project successful may serve only to encourage others to spend money on unsuccessful methodology.

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Reintroduction of Bobcats on Cumberland Island, Georgia: A Biopolitical Lesson

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Introduction

We describe the process through which we integrated our research objectives with management objectives of the National Park Service (NPS) to reintroduce bobcats (*Felis rufus*) on Cumberland Island, Georgia. Specifically, this paper describes Federal environmental assessments conducted, public perceptions and concerns expressed, prerelease evaluations performed and preliminary results of our reintroduction effort. The major lesson we learned was that projects designed to reintroduce native wildlife species may not be publicly or politically acceptable in and of themselves. Wildlife biologists should devote significant effort to information and education programs during the early project planning stages to ensure public understanding, acceptance and approval of wildlife reintroduction projects.

Cumberland Island, the NSP and Bobcats

At more than 20,000 acres (8,100 ha), Cumberland Island is the largest in a series of barrier islands extending from Cape Hatteras, North Carolina to Talbot Island, Florida. The island contains at least 22 recognized vegetative types, ranging from dunes to maritime forests (Hillestad et al. 1975). European settlers have occupied the island since the 16th Century, and have altered the island's ecology by harvesting timber, planting agricultural crops and releasing hogs, cattle and horses (Hillestad et al. 1975). Several major plantations and private estates were established on the island in the 18th and 19th centuries and were actively cultivated until the early 20th Century (Hillestad et al. 1975).

The National Park Foundation began purchasing land on the island in the late 1960s. Congress established Cumberland Island National Seashore (CINS) in 1972 (Public Law 92–536), and designated much of CINS as a wilderness area in 1982

(Public Law 97–250). Congressional directives to the NPS for management of CINS included providing for public outdoor recreational use of shoreline lands and waters and preserving related scenic, scientific and historic values, including the seashore's primitive state and its unique flora and fauna. The enabling legislation for CINS permitted hunting, fishing and trapping on the seashore.

The Resources Management Plan for CINS (U.S. National Park Service 1983) specifically addressed preservation and management of numerous wildlife species. One specific project under the Plan was documentation of extirpated species and preparation of environmental impact statements for reintroduction (CUIS-N-5007). Among the mammalian species listed as probable former residents of the island, the Plan recommended the bobcat receive the highest priority for reintroduction because it would be less likely than other predators to conflict with visitors or island residents. Bobcats characteristically avoid humans and rarely constitute a threat to domestic animals (McCord and Cardoza 1982). Bobcats were last reported on the island around 1907. According to Harper (1927:321), "Isaac F. Arnow stated that the species was common on Cumberland Island up to about 1907, when some disease exterminated it there." Subsistence hunting, deliberate persecution and disease probably caused extirpation of several species of mammals from Georgia's coastal islands (Johnson et al. 1974).

Preparation for the Reintroduction Project

The NPS planned to contract the reintroduction of extirpated species to university-based researchers (U.S. National Park Service 1983). Funding was available only to achieve the management goal of reintroducing bobcats to CINS; however, the project afforded a unique opportunity to conduct research on predator ecology in a relatively isolated area where bobcat density could be controlled experimentally. Therefore, we developed a more complex research proposal that included joint funding from the University of Georgia, the U.S. Fish and Wildlife Service and the Georgia Department of Natural Resources (DNR).

The proposal (Warren and Conroy 1987) included four research objectives: (1) evaluate the effectiveness of the reintroduction effort in terms of bobcat survival and reproduction, (2) identify seasonal food habits and prey preferences of reintroduced bobcats, (3) ascertain their seasonal movements, habitat use and social organization and (4) evaluate the scent-station survey method of estimating bobcat population abundance under known increases in bobcat density. We expected to achieve the overall management goal of reintroducing bobcats to CINS in the process of meeting these research objectives. Funding was approved early in 1988 and three graduate students were recruited to conduct the research as part of their graduate programs.

Environmental Assessment

The National Environmental Policy Act (NEPA) (Public Law 91–190) requires consideration of environmental effects from proposed Federal actions. Our proposed bobcat reintroduction project involved Federal funding and public lands. Therefore, prior to any reintroduction effort on CINS, we were required to prepare an Environmental Assessment (EA). Guideline NPS-12 (National Park Service 1982) defines an EA as the initial environmental document used in planning and decision-making to determine whether a proposed action may or will have a significant impact on the quality of the human environment, in which case an Environmental Impact Statement must be prepared to ensure NEPA compliance. The decision-making process usually includes formal public review and comment on the EA. In cases of no expected significant impacts from a proposed action, a Finding of No Significant Impact (FONSI) must be prepared subsequent to the EA and be made available for public review (U.S. National Park Service 1982).

We prepared the EA for the CINS bobcat reintroduction project with input from NPS officials. We had to justify the proposed reintroduction effort and consider possible environmental effects even though we were proposing to restore a formerly native species to the island. We justified the proposed project from the standpoint of restoring ecological control over several species of native and exotic herbivores by restoring a native predator to the island's ecosystem. The EA cited habitat alterations that were occurring on many areas of the island from heavy grazing and browsing pressures from white-tailed deer (*Odocoileus virginianus*), feral horses (*Equus caballus*) and feral hogs (*Sus scrofa*) (Hillestad et al. 1975, Ambrose et al. 1983, Turner 1986). Among the alternatives to the proposed project we identified were a less desirable trapping and removal program and the required "no action" alternative. We considered each alternative for possible environmental impacts, including effects to visitors and retained-rights residents on the island.

We cited published literature to support our contention that bobcats could kill healthy, adult deer (McCord and Cardoza 1982, Anderson 1987). A study in coastal South Carolina habitats documented that "high predation rates of fawns, in addition to other important mortality factors, were an effective natural control on a dense, healthy, unhunted deer population, and probably contributed significantly to herd stability for the past 30 years" (Epstein et al. 1985:378). Of the four predators on that particular study area, the bobcat was the most important predator on deer fawns, accounting for 12 of 18 known predator-caused deaths (Epstein et al. 1983). We cited a food habits study from Florida (Maehr and Brady 1986) to consider other prey species consumed by bobcats in similar habitats.

The EA briefly mentioned the possibility of bobcats preying on wild turkeys (*Meleagris gallopavo*), but discounted this because of the contention that predation is not a principal limiting factor of turkey populations (Markley 1967). The question of predation by bobcats on turkeys proved later to be one of the major sources of public opposition to the proposed reintroduction project.

An unexpected concern occurred during our assessment of the likely environmental impacts of our proposed reintroduction. In our considerations of possible prey of bobcats, we included rodents and consulted the U.S. Fish and Wildlife Service's Endangered Species Office in Jacksonville, Florida. They advised us that the Anastasia Island beach mouse (*Peromyscus polionotis phasma*), which was initially thought to occur on Cumberland Island, had been proposed for listing on the Federal Endangered Species List in November 1987 (D. J. Wesley pers. comm. 1988). We conducted, and included in the EA, a detailed literature review of the taxonomy and distribution of *Peromyscus* spp. in the vicinity of Cumberland Island. We were able to document that the Anastasia Island cotton mouse (*P. gossypinus anastasae*), and not the Anastasia Island beach mouse, was the more likely resident of Cumberland

Island. A recently published status survey for the Anastasia Island beach mouse indicated it did not occur farther north than St. Augustine, Florida (Humphrey et al. 1987). Thus it would not likely be affected by our proposed reintroduction of bobcats on Cumberland Island.

Hillestad et al. (1975) reported three bobcats were released on the island in 1972 and 1973. Prior to our proposed reintroduction effort we had to ascertain whether or not any of these individuals or their progeny were still present on the island. Thus, with the aid of Georgia DNR furbearer biologists and local bobcat hunters, we surveyed the island for two days in April 1988. Surveys of roads and trails adjacent to favorable bobcat habitat on the island revealed no sign of bobcats (e.g., tracks, scats), and we concluded it was unlikely that bobcats were present on CINS at that time (Conroy and Warren 1988). Later pre-reintroduction scent-station surveys corroborated this conclusion (Conroy et al. 1989).

Public Review and Comment on EA

Written Comments Received

We worked closely with the superintendent of CINS during the 30-day public review and comment period (required by NPS-12). He gave public notification in August 1988 of the EA and solicited public comments on the proposed bobcat reintroduction project by distributing direct mailings and news releases. We also scheduled two public meetings in September 1988. Official news releases regarding the EA and the project also were promulgated by the Southeastern Regional Director of NPS.

The NPS received 17 written comments regarding the project: one petition with 51 signatures and two letters from individuals opposed to the reintroduction of bobcats and four letters from organizations, one letter from a state agency, one letter from a congressman and eight letters from individuals endorsing the proposal.

The Wilderness Society supported the proposed project as described in our EA, but raised the question of sterilizing bobcats prior to release until their complete ecological effects on the island were determined (S. C. Whitney pers. comm. 1988). They further commented that the presence of bobcats within the natural system might enhance the wilderness experience for backcountry users of CINS. The knowledge of a native predator stalking the woods, whether actually seen or not, would provide an important psychological influence over the quality of the wilderness experience (S. C. Whitney pers. comm. 1988). In a survey of 1,083 visitors to Yellowstone National Park, McNaught (1987) similarly found that 74 percent felt the presence of reintroduced Rocky Mountain gray wolves (*Canis lupus irremotus*) would enhance their experience in the park.

The Georgia Chapter of the Sierra Club also supported the project, but questioned the true focus of the EA as to whether the proposed action was designed to reintroduce bobcats specifically, restore CINS to a more natural state or to consider the best method of controlling exotic species on the island. This raised the broader question of whether native wildlife species should even be controlled on NPS areas (W. E. Mankin pers comm. 1988). The EA did not sufficiently convey the details described in the original research proposal (Warren and Conroy 1987). In retrospect, attaching the research proposal, or indicating it was available upon request, would have improved the public review and comment stage of the project.

Some residents on the island were opposed to the reintroduction because of fear of bobcats attacking pets or children (C. H. Candler, II pers. comm. 1988). Conversely, other individuals indicated that bobcats would "constitute no threat to campers, and only the luckiest and most observant (would be) likely to see one even if a considerable population of bobcats were developed" (B. S. Bullock pers. comm. 1988). In his survey of Yellowstone National Park visitors, McNaught (1987) found fewer than 20 percent of those surveyed expressed concern that reintroduced wolves might threaten human safety.

One source of major local objection to the project arose in letters from two individuals and in a petition signed by a group of 51 persons who opposed reintroduction of bobcats to the island for the purpose of deer population control. They advocated increased use of organized hunts and professional hunters as a more cost-effective means of deer population control. Among the concerns expressed by the petitioners as to why bobcats should not be released on the island were: (1) the bobcats would "eat all the turkeys," (2) "campers will be scared of them," (3) "(we) soon (will) have a bobcat problem" and (4) "we can't eat bobcats." Regardless of the humor in some of these comments, this source of opposition to the project indicated that our initial justification (i.e., deer population control) was inappropriate. Indeed, if the primary objective of the proposed reintroduction was to control the deer herd on the island, it could conceivably have been achieved more cost effectively by other methods. Furthermore, the greater question, which had policy implications, was whether or not NPS should institute management programs to control populations of native wildlife species on lands it manages. The "deer control" issue was the primary aspect emphasized in much of the media coverage the project received and in the controversy generated during the public review and comment stage of the project.

One totally unexpected source of opposition to the proposed project came from the six-member City Council of St. Mary's, Georgia. The Council voted four to one to send the Georgia DNR a resolution expressing opposition to the proposal. They were opposed to the project because they felt it was inhumane to place bobcats on the island, and that they would decimate the island's wild turkey population. Wild turkeys are native to Cumberland Island, but the species likely was extirpated and later replenished by releases from pen-raised stock of semi-domestic origins (Johnson et al. 1974, Hillestad et al. 1975).

This aspect of the public review and comment stage of the project generated a great deal of controversy, perhaps because of the local political interests involved. In response to concern over turkeys and to put the controversy in proper perspective, we prepared and made available for public distribution by NPS a six-page literature review. It described sources of turkey mortality, effects of predation on turkey populations, the role of bobcats as turkey predators and the Cumberland Island turkey population. Biologists from Georgia DNR also assisted in alleviating public concerns by their comments to news media, stating that bobcats would not wipe out turkeys, and might even improve their gene pool as less wary individuals were removed from the population.

In retrospect, we failed to anticipate the potential controversy associated with the proposed reintroduction project. We likely could have identified the public opposition concerning control of deer and decimation of turkeys on the island prior to beginning the EA review. Had we done so, the public review and comment stage of the project likely would have been much less controversial. We should have contacted several local, influential persons early in the project planning stages to identify their concerns so they could have been addressed in the EA before it was sent out for public review.

Public Meetings to Review the Proposed Project

Most written comments were received before the official public meetings in St. Marys and Athens, Georgia. Based on written comments received, we realized our initial justification of the project from the standpoint of controlling herbivores (especially deer) on the island was a mistake. Official NPS statements also indicated emphasis on deer control in the initial EA was a mistake. In subsequent news releases and in the public meetings, we stated the major justification of the project was to reintroduce a formerly native species to restore biological diversity. Further, we emphasized that Congress requires NPS to manage park lands to maintain abundance, behavior, diversity and ecological integrity of native animal life in natural portions of parks (16 USC 1, 2–4).

We were present along with NPS officials at both public meetings. The meeting in St. Marys was uneventful and was largely unattended. The meeting in Athens was purposefully sited to be accessible to northern Georgians, especially those from Atlanta. We presented a brief slide discussion of the island, its habitats, and its wildlife, after which questions were answered. After having discussed bobcats, details of the proposed project and possible environmental concerns, most persons seemed to understand and appreciate the need for the project.

Media Coverage

Most news coverage the project received focused on our initial justification in the EA (i.e., deer control). Newspaper article titles such as "State to use bobcats to kill Cumberland deer" (*Florida Times Union*, Friday, 12 Aug. 1988, page B1) and "Bobcats coming to Cumberland Island to thin deer herd" (*Jacksonville Journal*, Friday, 12 Aug. 1988, page 3A) helped focus most public attention on what we later realized was an incorrectly restrictive justification for the project.

Later news coverage focused on the political controversy that developed involving the St. Marys' City Council. Newspapers want news, and conflict is an important human interest angle that can make even a generally unappealing topic into news (Fazio and Gilbert 1986). Newspaper article titles such as "St. Marys claws at Cumberland bobcat plan" (*Florida Times-Union*, Wednesday, 24 Aug. 1988, page B1) appeared to create a greater controversy than actually existed. This controversy even received television news coverage. At least one television station in Atlanta (WSB-TV2) aired a story on the nightly news detailing the proposed project and the controversy, in which the Chairman of the St. Marys' City Council and the Superintendent for CINS were interviewed. The newscast ended with the smugly humorous comment that there would likely be a "lot of growling" before the decision was made regarding the release of bobcats on CINS.

The idea of a controversy surrounding the proposed project grew even greater as time neared for the public meetings. Several newspaper reporters were present at the public meeting in Athens, and at least one indicated he had come to the meeting specifically because of the controversy (Steve Goldberg, pers comm., 1988).

News coverage subsequent to the public meetings was more "balanced" and presented the proposed project in its complete context. Unlike in the earlier news coverage, we had direct input and often were interviewed personally in the later news articles. Newspaper articles such as "Bobcats to return to Cumberland Island" (*Atlanta Journal*, Friday, 30 Sep. 1988, page 15A) and "More bobcats freed on Cumberland" (*Atlanta Journal*, Friday, 4 Nov. 1988, page 1D) de-emphasized the controversial aspects and emphasized the broader ecological significance of the project.

Project Approval and Preliminary Results

We cooperated with NPS staff in preparing the agency's response to public comments received. Ultimately, the regional director of NPS issued a FONSI in October 1988 to allow the project to proceed and the first releases to occur. The FONSI clarified the EA by answering several specific questions that arose during public review: (1) What is the true focus of the EA? (2) Should native wildlife species be controlled? (3) What about previous reintroductions? (4) What are the details surrounding the proposed reintroductions? (5) Will bobcats attack people, pets, or horses? The FONSI concluded the proposal did not constitute a major Federal action with significant effects on the human environment, and hence no EIS was required.

Timing of project approval was critical. We began trapping bobcats along the Georgia coast in August 1988 in anticipation of project approval and had trapped a sufficient number of bobcats for the first scheduled release in October 1988. We became concerned that we might be required to delay the reintroduction when the project began receiving public opposition. Fortunately, the period for public review and project approval proceeded in a timely manner and did not delay the first year's releases. In retrospect, we should have prepared the EA sooner. A less hurried process would have allowed us more time to assess local public concerns and to implement appropriate information and education programs.

Prior to the first release of bobcats, we prepared a three-page information release for use by NPS staff in their introductory orientation for visitors upon arrival at CINS. Included was general background information on bobcats, their natural history, the bobcat reintroduction project, and benefits. A common misconception of visitors and residents on CINS was the size of bobcats and their potential threat to humans. We have no objective measure of the extent to which this information release benefitted the project, but we believe it helped.

We released 14 wild trapped adult bobcats (3 males and 11 females) in 1988. Four were released on 13 October, 6 on 3 November, and 4 on 28 November to create known increases in bobcat density to evaluate the scent-station index. Prior to release, bobcats were quarantined, vaccinated with a modified, live virus for feline panleukopenia, calicivirus and rhinotracheitis, and fitted with radio-telemetry collars. One female was found dead in January 1989. Necropsy revealed she died from injuries, possibly inflicted by a feral hog. In February 1989, one female swam to the mainland, a distance of 1–2 miles (1.6–3.2 km) of open water and salt marsh. All other bobcats released in 1988 survived and remained on the island. During summer and fall 1989, we retrapped three adult bobcats released in 1988 and recorded body weight gains of 13–37 percent. We found 10 kittens in four dens in April 1989; each female had 2–3 kittens. We released 18 bobcats (12 males and 6 females) in 1989—6 on 5 October, 6 on 25 October and 6 on 4 December. One male released in an interdune area swam into the Atlantic Ocean and apparently drowned. All other bobcats released in 1989 have survived to date, thereby bringing the total number of adults on the island to 29.

The project's goal of reintroducing a previously extirpated predator into its former habitat has been successful to date. A translocation is a success if it results in a self-sustaining population (Griffith et al. 1989). Based on preliminary data, the bobcats reintroduced on CINS are surviving and reproducing well. Continued population monitoring, possibly to include genetic evaluations, will be needed to ascertain the long-term viability of this reintroduction.

Epilogue

Justifying reintroduction of bobcats to CINS based on controlling the deer population on the island continued to plague us long after the public review and comment period elapsed. In April 1989, an article was released by the Associated Press wire service entitled "Bobcats not reducing Cumberland deer level" (*Athens Daily News*, Friday, 7 Apr. 1989, page 7A). The article stated that "14 bobcats released on Cumberland Island last fall have not reduced the deer population as expected. . . ." despite the fact that bobcats had been on the island only about six months.

This media misconception was further amplified when an article appeared in the October 1989 issue of *Outdoor Life*—"Georgia cat reintroduction projects fail" (Hunter 1989). In this article, Hunter (1989:10) stated "two wildlife projects that have greatly interested Georgians this year have been deemed failures. . . ." (S)ince the 14 bobcats were put on the island, they have done little to control the deer population. . . ." the article continued.

Obviously, it is unreasonable to expect an immediate response of a prey population to a reintroduced predator. We are monitoring prey populations via seasonal surveys and estimating the occurrence of prey items in bobcat diets by analyzing scats. These data should enable us to infer effects of bobcat predation on prey species such as white-tailed deer.

We learned several important biopolitical lessons during our efforts to reintroduce bobcats on CINS. We should not have placed ourselves in the position of defending the reintroduction as a means of controlling populations of herbivores. We erred by not emphasizing the original objective of restoring biodiversity, as outlined in NPS documents and our original research proposal. We underestimated public support for a reintroduction for its own sake (that of restoring a native predator) and oversold the idea of a predator as a controlling agent. Formal and informal surveys of public concerns should be incorporated early in the planning stages of reintroduction projects. These surveys can provide the basis for an information and education program that likely will lessen public opposition to, and expedite public approval of, wildlife reintroduction projects. Reintroduction efforts should be justified based on a straightforward, primary objective. In our case, bobcats had existed previously on Cumberland Island and should be reintroduced to restore one aspect of the island's original fauna. Auxiliary benefits, if any, should be de-emphasized so that failure to achieve them would not constitute a "failure" of the reintroduction. In the final analysis, complete and correct information is critical to the public's understanding and support of any wildlife research or management program, including reintroductions.

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Restoration of Lynx in New York: Biopolitical Lessons

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This paper describes the biopolitics of a predator restoration effort spanning a continent and two nations. Although the project is still in progress, we present this early report so the lessons we have learned may benefit others. The successful initiation of this effort owes much to its long gestation. From its inception, project activities were embedded in a complex political setting.

Project Gestation

Restoration of lynx (*Felis lynx*) is currently underway in the northeast sector of New York's Adirondack Park, the High Peaks Region, a wooded mountainous area with more than 40 peaks exceeding 1,200 m elevation. Political protection of Adirondack Park reached a threshold in 1971 with legislative creation of the Adirondack Park Agency (APA). This agency has the large task of regulating land use with zoning restrictions and protecting the Park from rampant development in an area of 6 million acres (2.4 million ha), an area larger than the state of Massachusetts. Unlike other parks, almost 60 percent of Adirondack Park is in private ownership. Private lands and villages are scattered throughout and are interspersed with large blocks of publicly-owned Forest Preserve Lands (Figure 1).

Political protection from development was first conferred on Forest Preserve Lands in 1855 by the ''forever wild'' provision of Article 14 of the New York State Constitution. The State's battle to acquire these lands in the Adirondack region and to restrict public use to wild land recreation has been long and politically acrimonious (Graham 1978). Urban political power blocks favoring restricted use and preservation were ranked against local residents opting for private land development and more intensive use of public Forest Preserve Lands. Even though Park residents overwhelmingly opposed the legislative creation of APA in 1971, the political power of urban blocks prevailed.

This experience left a large residue of resentment among Park residents, directed against urban ''outsiders'' they perceive to be anti-development preservationists. These negative feelings also tend to predispose local residents against predator restorations. They believe such projects are intrusions on their affairs and ''their'' natural resources. Creation of APA also kindled resentment in the early 1970s among professionals of the New York State Department of Environmental Conservation (DEC), legally entrusted with management and conservation of the State's natural resources. While these differences have since been resolved, the perception of DEC personnel at that time was that APA was treading on their turf.

In this somewhat hostile climate, the lynx restoration project was born. In 1971, C. H. D. Clarke (1974) proposed in his ''Wildlife Technical Report for the Tem-

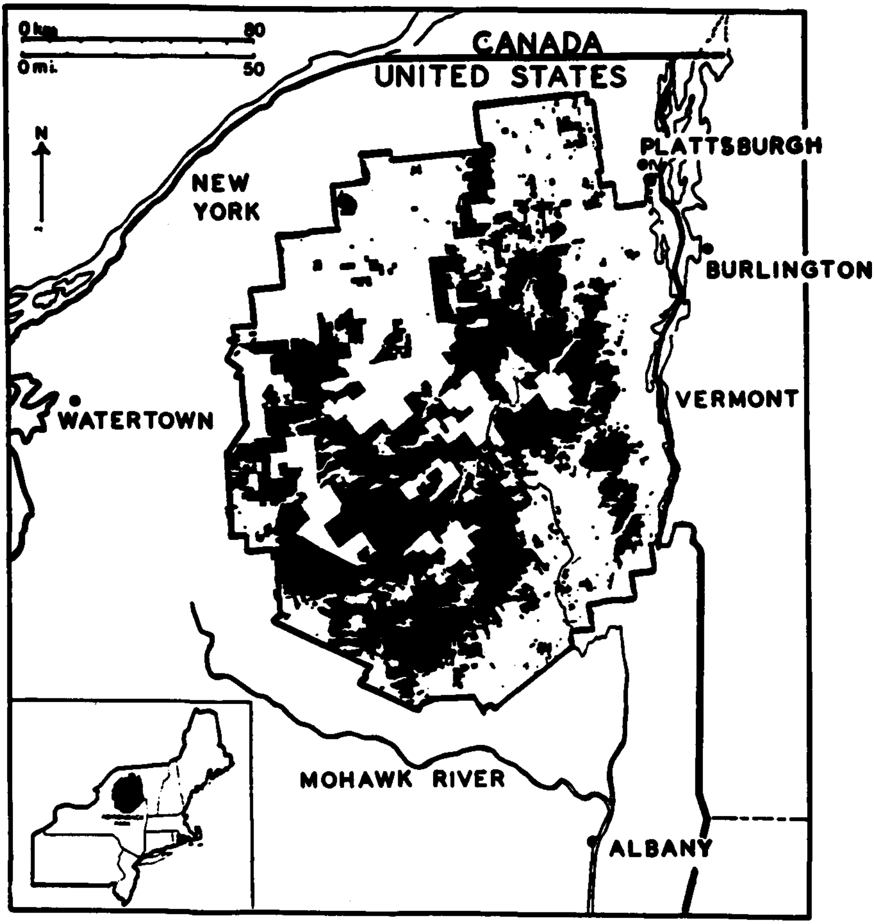

Figure 1. The Adirondack Park is a patchwork of public (black) and private lands.

porary Study Commission on the Future of the Adirondacks'' (this commission preceded the APA) that efforts should be made to restore extirpated Adirondack wildlife species. By the mid-1970s, however, there had been no movement to implement Clarke's recommendations. In 1976, the senior author convened a group of university scientists, private conservationists, as well as key biologists and administrators of the DEC and APA. Naming itself the Adirondack Wilderness Fauna Program (AWFP), this group decided the time was ripe to initiate ecological studies on rare and declining wildlife species in the Park and to conduct feasibility studies on restoration of extirpated species. AWFP scientists produced a comprehensive proposal seeking funds for 15 studies (Brocke 1976). Most proposed research projects were eventually funded and completed, including feasibility studies to restore lynx (Brocke 1982b), mountain lion (*Felis concolor*) (Brocke 1981) and peregrine falcon (*Falco peregrinus*) (Loucks 1982). Also completed were ecological studies and surveys on common loon (*Gavia immer*) (Hicks and Allen 1979, Parker 1988), spruce grouse (*Dendragapus canadensis*) (Bouta and Chambers 1987), eastern coyote (*Canis latrans*) (Chambers 1987) and rock vole (*Microtus chrotorrhinus*) (French and Crowell 1985). A study on the history of Adirondack wildlife was also completed (VanDruff et al. 1990).

AWFP researchers had hoped for large-scale funding to support their holistic package of research projects. However, studies were funded piecemeal and by traditional sources, primarily through DEC's Pittman-Robertson and Endangered Species Program funds, with some support from sportsman's organizations and an Audubon Club. AWFP participants met annually or biennially through the early 1980s. This meeting framework served admirably as a forum for communication. Yearly research progress reports galvanized the group. AWFP participants informed their respective agencies and organizations about ongoing research and discussions, opening lines of communication and building a climate of trust among this diverse group of scientists, wildlife managers, lay persons and administrators.

With completion of most research projects, AWFP activities would down in the early 1980s. The DEC followed up with a successful peregrine falcon recovery program and loon surveys in Adirondack Park. However, the positive recommendations of the lynx feasibility study (Brocke 1982a) awaited action. In 1984, the New York State Legislature, inspired by the former AWFP activities (Brocke 1982b), contracted the State University of New York, College of Environmental Science and Forestry (ESF) to develop and implement a new program, the Adirondack Wildlife Program (AWP). The objectives of this program are: (1) continue Adirondack wildlife studies, including research associated with DEC-implemented wildlife restorations in the Adirondacks and (2) develop an educational program for New York schools using results of Adirondack wildlife studies to illustrate the scientific process. Launched in 1985 and funded primarily by the State Legislature, the AWP has been active to date. The program is implemented by seven ESF faculty, 12 graduate students, an educational coordinator and assistant, two co-directors and an advisory committee representing the general public, Audubon Society, National Wildlife Federation, sportsman's organizations, Adirondack organizations, the State Legislature, DEC and APA. The lynx restoration project is one of the 15 studies comprising AWP's research component. An annual two-day meeting brings the advisory committee in direct contact with researchers, graduate students and research activities.

The launching of AWP in 1985 and simultaneous publicity surrounding release of the lynx feasibility study results did much to gain general public acceptance for lynx restoration in New York. However, strong opposition remained among hunter and trapper organizations and Adirondack residents. In 1985 the senior author convened a conference entitled: "Man and Wildlife in the Adirondacks: Past, Present and Future," co-sponsored by ESF and DEC. This conference was well attended by professionals and representatives of several key interest groups. It marked a turning point and did much to dissipate remaining apprehensions among hunter and trapper organizations, some agency professionals and the public. Preparations for lynx restoration under DEC permit began in 1986.

In retrospect, we gained in several ways from the long project gestation period, spanning almost 10 years. It was an unhurried period, allowing professionals and other participants to get to know each other on a collegial basis. It afforded time to conduct thorough feasibility studies and maintain a subdued but continuous dialogue with the public through occasional lectures and seminars. Unlike the ill-fated gray wolf (*Canis lupus*) restoration attempt in Michigan (Weise et al. 1975), there would be no surprise predator restoration for the public, with negative consequences later. The comprehensive frameworks of both AWFP and AWP provided, in their diversity, something exciting for most public interest groups and participants, be they enthusiasts for loon, peregrine falcon, spruce grouse, mountain lion, wolf, coyote, lynx, bobcat (*Felis rufus*), white-tailed deer (*Odocoileus virginianus*), moose (*Alces alces*) or the Adirondack ecosystem. Through regular AWFP meetings, university scientists were exposed to management problems and perspectives of agency biologists. On their part, agency biologists had the opportunity to appreciate the value of university resources to conduct solid research, a point stressed by Temple et al. (1986). Finally, continuity of the AWFP and AWP frameworks projected a sense of serious commitment to the public.

Operations and Special Interest Groups

Key findings of the feasibility study (Brocke 1982a) were: First, the bobcat, a resident of Adirondack Park, was a potential competitor of lynx. However, the Adirondack bobcat population was sparse (Fox and Brocke 1983) and bobcat activities were concentrated below 800 m. Second, the best potential colonization area in Adirondack park was the High Peaks region, an area with a mean elevation exceeding ;800 m. This region was classified in the APA's "wilderness" land-use category and was penetrated only peripherally by roads. The estimated area suitable for lynx restoration was approximately 7,170 km^2 (670 square miles). Third, large tracts of conifer habitat with good snowshoe hare (*Lepus americanus*) populations [July hare density = 170 hares/km^2 (440 hares per square mile)] were distributed throughout this area. We estimated that available habitat and prey would support approximately 70 lynx. The plan was to acquire lynx directly from the wild from cooperating trappers, holding them for as short a time as possible before release in the Adirondacks.

Eighteen lynx were released in the High Peaks during winter 1988–89 with plans to release 30+ in winter 1989–90. Our source of lynx has been near Whitehorse, Yukon Territory, Canada. We have established an effective working relationship with the Yukon Department of Renewable Resources (YDRR) and local cooperating trappers, thanks to generous assistance and facilitation of YDRR biologists, administrators and the Minister of Renewable Resources.

When we first approached the YDRR, we learned that export of live lynx was illegal, following a recently enacted legislation. This legislation had been supported by Yukon trapper organizations and native associations who feared that exported live lynx would be used to establish fur farms, thus compromising their economic returns from trapping, generally their livelihood. Thus, while the YDRR was willing to issue us a permit, this could not be done without the support of Yukon trappers to allow export. Two YDRR wildlife biologists were indispensable in opening lines of communication between us and Yukon trappers. Through a series of meetings with trapping organization leaders and key trappers, as well as an article about our restoration program in the trapper newspaper, Yukon trappers agreed to support our program. This issue was crucial for Yukon trappers and some meetings were heated. A few trappers wished to export live lynx themselves to fur farms because of the high rate of return (e.g., for live lynx, we pay 2–5 times the going rate for fur), and thus felt envious of "outsiders" from New York who might be granted a license. However, we received the needed trapper support and the export permit from YDRR. With the crucial assistance of the two YRDD wildlife biologists, local trappers were recruited as cooperators to capture live lynx for us.

Among trapper organizations in New York State, we initially also encountered strong resistance to lynx restoration. The lynx had been classified as a game animal with a closed season by DEC, making it illegal to kill or take the species under any circumstances. This status was expected to be permanent by the DEC. Trappers felt that lynx restoration could be used as a legislative lever by anti-hunting, anti-trapping or preservationist groups to close the restoration area to trapping and hunting. We presented our case at several trapper meetings and eventually enlisted the support of New York trappers. A protocol was developed for releasing accidentally-trapped lynx and reporting lynx trappings or sightings to us. Illustrations of the lynx's identifying characteristics and a brief description of our restoration program were contained in supplements of DEC's hunting and trapping guides. Knowing that lynx populations would not be managed by trapping in New York, the principal trapping organization in the state nevertheless made a substantial contribution to the lynx program, the first major donation by a public group. It also dedicated the 1988 annual meeting to the lynx, using a shoulder patch with a lynx logo for that year. The support of trappers has been crucial to the program, both for procurement in the Yukon and restoration in New York. Of all the publics, we have found that trappers are most knowledgeable about the appearance and habits of wildlife, a point supported by Kellert's (1986) survey of public attitudes towards the wolf. For us, sighting reports and other information contributed by trappers have been most useful.

In the Yukon, a rented trappers cabin served as our base for lynx acquisition for two winters. One of us (A. R. Major) coordinated Yukon operations during winters 1987–88 and 1988–89. At ESF's Adirondack Ecological Center (AEC) in the central Adirondacks, K. A. Gustrafson and R. H. Brocke supervise lynx restoration, research and communication with the public. In the Yukon, trapped lynx are brought by snowmobile and truck to our Yukon base, where they are held for observation in a heated pen complex. Following inspection by a veterinarian and YDRR official, if the animal is in good health, the trapper is paid and the animal released for shipment. Lynx are shipped by air freight in kennels from Whitehorse to Toronto. They are again held for one or more weeks at our AEC pen complex before being moved to the release site. All lynx have radio collars with mortality mode and are radio-tracked by light plane.

Publicity and Public Support

Since the lynx restoration program began in 1985, we have made scores of presentations, including illustrated lectures, seminars and technical papers. We have communicated with lay audiences, service clubs, Audubon clubs, Adirondack village audiences, organizations dedicated to preserving the Adirondacks, hunter and trapper organizations, school groups, legislative staffers, the state fair, and TV audiences. Additionally, AWP educational staff and AWP researchers conducting other studies, briefly cover the lynx restoration program along with their own topics. While this approach has been labor-intensive, we believe it is the most effective way to communicate with the public and make friends for a restoration project. Local residents should feel that they have a stake in the project. We believe this approach is effective because the public does not seem to perceive it as unfair progagandizing compared to canned TV programs. Our presentations are usually unhurried, the audience can ask questions and participate in discussion while the presenter is obliged to respond honestly, person to person. The lynx is far less controversial than most larger predators and most New York residents are delighted with the prospect of lynx restoration. However, some Adirondack residents worry about the safety of their children and pets. Farmers worry about livestock, and hunters are apprehensive about depressed hare or deer populations. Fortunately, there is little to fear from the lynx on any score.

There is a current tendency among conservationists to trifle with human fears and reactions to predators (O'Gara 1982). It is claimed that negative feelings can be overcome by "education." Education, in this context, is often perceived to be a superficial exercise in videotape propaganda. These fears can be diminished quite readily in most of the world where large predators are found only in zoos. Residents of wild and remote restoration areas have to live with their fears, enhanced by the visual presence of predators and their kills. Perhaps our fear and admiration for predators is genetically ingrained through our long evolutionary relationship with them, a relationship that has left a rich legacy of human traditions, symbols and rites incorporating predators (Campbell 1983).

In restoration of large predators, we firmly believe that human fear of predators, real or imagined, must be respected. Restoration should not begin without the substantial support of local residents. A hostile populace can vote directly with guns and traps against the predator being restored, as happened in Michigan (Weise et al. 1975).

A signal event was the release of the first five lynx on 11 January 1989. Until that time, there had been scattered newspaper articles and wire service reports about the project. We realized the first release would afford an unparalleled opportunity to accommodate the press and tell our story. Our AWP educational coordinator contacted all major newspaper editors in the State, inviting them to attend an illustrated presentation on the evening of 5 January, followed by dinner and overnight lodging at our expense. The following morning, reporters could take photos of lynx at the holding pens, prior to an auto trip to the trailhead. There they could "send off" the restoration party, carrying the lynx in portable cages to the High Peaks release area. The event exceeded our wildest expectations for success. All major newspapers, including the *New York Times* sent reporters to the event. In addition to their own notes and photos, each reporter was given an information package and stock photos. The evening dinner and talk provided an unhurried opportunity for reporters to interview project scientists. On the day of the release, agency and college administrators, the Speaker of the New York House of Representatives, a PBS-TV crew and students who volunteered to carry the lynx milled around happily at the trailhead. Reports were well satisfied with the many photo opportunities.

The result was solid coverage by every major newspaper in the State. There was also good coverage in local newspapers as press packages had been sent to them announcing the release. An hour-long television production by PBS-TV, Schenectady, featured lynx project operations in New York and the Yukon. The producer made a special trip to the Yukon to shoot a lynx trapping sequence. This feature has been aired in the U.S. and Canada.

Press coverage on the first lynx release triggered an avalanche of public support. Congratulatory mail arrived almost daily. Most letters contained donations, although none had been solicited. Donations from individuals ranged from 75 cents to $1,700. Foundations and organizations donated up to $10,000 individually. Roxboro Middle School in North Syracuse developed its annual school project around a fund drive for lynx restoration. Spearheaded by an enthusiastic teacher, the upper grades developed a library research project on lynx ecology, aided by the AWP educational staff. The students sold $27,000 worth of chocolates to the community and donated $8,500 in profits to the lynx project. Culminating their efforts, the students held a special assembly in honor of the lynx restoration program. Following an illustrated show on lynx ecology, the students sang their newly composed song: "And the lynx came back!" A busload of students visited the state legislature to witness donation of their $11,000 check to the lynx project, while a local congressman and the House Speaker looked on. Again, more press coverage and good publicity.

The importance of Information and Education programs has long been recognized (Leopold 1933, Gilbert 1971, Allen 1973, Case 1989). Yet, public support for wildlife management projects is often listless. As professionals, we know what to do but neglect to take advantage of our opportunities. As we watched events unfold, we were stunned by the high level of public support that this project generated. As a flagship project, it played a large part in generating strong public and sponsor support for the entire AWP research and education program. We were blessed with an appealing project and much good luck, to go along with the planning and hard work. We feel that the following procedures worked well for us and show promise for similar restorations:

1. A thorough feasibility study buys valuable time to begin exposing the public to a potential restoration. Dimensions of the public's reactions will become apparent during this period. It should be clear to the public that restoration itself has not begun, nor will it begin without strong public support, pending a positive recommendation of the feasibility study.
2. The AWFP and AWP frameworks were effective in several ways. Much can be gained by including a predator restoration project within a complex of other projects. Together, they should have broad appeal to many interest groups. One project alone is an inviting target for negative political action.
3. The AWFP framework was particularly useful in opening lines of communication between personnel of universities conducting research and the DEC, principal wildlife agency entrusted with management. These missions are entirely complimentary. An informal AWFP-type framework focused on a regional wildlife issue can build collegial relationships and yield important dividends in cooperation.
4. The public is keenly interested in prominent wildlife species, whatever their perceived values. Representatives of public interest groups, including organizations for hunters, trappers, conservationists and preservationists should be included early in the circle of communication. An AWFP type framework is useful for this purpose.
5. Advisory and technical committees are effective mechanisms for communication

and direct cooperation. They help update representatives about progress of the restoration project.

6. Legislators who have a personal interest in a particular restoration project are powerful allies. Commonly, a layer of administrators is interposed between the legislator and restoration activities in the field. A field meeting provides substantial opportunities for direct communication between the legislator and the "troops," namely individual researchers, students and management biologists actually conducting the work.
7. A thorough publicity program with input from both public relations experts and project personnel is effective. However, we believe that continuous and direct dialogue between project personnel and the public is the best form of publicity. Communication through illustrated lectures, seminars and public meetings is a two-way street. The public gains by learning directly from researchers or managers with specific answers to its questions. The project professional gains by directly sensing public thought and fine-tuning presentations to the audience. The public may be convinced that it has a stake in the project and it can be involved directly in some aspects. Most importantly, communication should be honest, forthright and consistent. The politics of natural resource conservationists have not infrequently created a perception among local residents that they have been disenfranchised. In such cases, they are outvoted and cannot fight back politically. But, a wildlife restoration tends to even the odds as residents can vote directly against predators with traps and guns.

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Planning to Reintroduce Woodland Caribou to Minnesota

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Woodland caribou (*Rangifer tarandus caribou*) historically occupied the boreal coniferous forest zone across the entire North American continent. Overall distribution and abundance of the species declined dramatically in the late 1800s and early 1900s (Bergerud 1974). This trend continued into the 1980s. The decline prompted a review of the species status in several provinces (British Columbia [Stevenson and Hatler 1985], Alberta [Edmonds 1986], Manitoba [Shoesmith 1986], Ontario [Darby et al. 1989]). Populations have been restored to portions of Quebec (Bonefant 1974) and Newfoundland (Bergerud and Mercer 1989), while a remnant population along the British Columbia -Idaho border was supplemented recently (Servheen 1987). Woodland caribou were reintroduced to Maine in 1989 (M. McCollough, pers. comm. 1990).

Distribution and abundance of woodland caribou in Minnesota declined as part of the continent-wide trend and only three adult females were known to be in the state by 1937 (Manweiler 1941). This small group was supplemented with 10 individuals from Saskatchewan in 1938 (Fashingbauer 1965). One male was released to join the remaining three free-ranging cows while the other nine animals were retained in a 4 square-mile (10 km^2) enclosure. The free-ranging group of 4 was not seen after 1940. In 1942, the nine captive animals and their progeny (some 15–20 animals) were released from the enclosure. There are no confirmed reports of these animals following their release (Fashingbauer 1965). With the exceptions of sightings of at least two individuals in extreme northeastern Minnesota during winter 1981–1982 (Peterson 1981, Mech et al. 1982), this was the last evidence of caribou in Minnesota.

The range of woodland caribou in adjacent Ontario and Manitoba continued to retreat northward. By 1985, the continuous distribution of caribou extended to approximately 50°N in Ontario (Darby and Duquette 1986) and Manitoba (Shoesmith 1986), with only remnant bands along the shoreline and islands of Lake Superior, Ontario (Darby and Duquette 1986).

Restoration of woodland caribou to Minnesota remains an attractive goal and challenge to sportman's groups, environmentalists, and agency and university wildlife biologists. Considerable planning for an introduction was done between 1976 and 1980 (Karns 1980). However, the impetus for an introduction was lost when funding was not provided by the Minnesota State Legislature. This paper reviews causes of the range reduction, the outcome of a previous planning effort, and describes an ongoing planning process. The latter may provide a structure for planning reintroductions of other mammalian species elsewhere.

Causes of Range Reduction

Hypotheses proposed for the decline in the distribution and abundance of woodland caribou (Bergerud 1974) include: (1) habitat destruction by logging and catastrophic fire, (2) increased hunting and predation, due in part to an increase in gray wolf (*Canis lupus*) density with an increase in other prey species such as moose (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*), coupled with transmission of meningeal brainworm (*Parelaphostrongylus tenuis*) to woodland caribou from white-tailed deer as the latter expanded its range north to colonize early successional forest stages caused by increased catastrophic fires and logging activities, or (3) a combination of both. Bergerud and Mercer (1989) suggested the continent-wide range decline was due primarily to increased hunting pressure and natural predation. However, the recent disappearance of three localized woodland caribou herds in Ontario was associated with logging activities alone with no evidence of increased predation, hunting or exposure to white-tailed deer (Darby and Duquette 1986).

Successful reintroduction of woodland caribou requires an understanding of: (1) reasons for the original disappearance of the species, (2) habitat requirements, and (3) potential interactions with native or non-native species in the proposed release area.

Early Planning Efforts

Subsequent to the failure of the effort to augment the woodland caribou band at Red Lake in the early 1940s, no efforts were made to reestablish the species in Minnesota until the mid-1970s. At that time the Minnesota Chapter of Safari Club International approached the Minnesota Department of Natural Resources with an offer to fund an investigation of the potential for reintroducing woodland caribou. The offer resulted in formation of an interagency planning group of representatives of the Minnesota Department of Natural Resources, Superior National Forest, U.S. Fish and Wildlife Service, Department of Fisheries and Wildlife, University of Minnesota, St. Paul, and the Minnesota Zoo.

The group identified a number of factors on which information was needed before a decision on the potential of reintroducing woodland caribou to Minnesota could be made. These included: (1) habitat availability, (2) presence of white-tailed deer and incidence of brainworm in these deer, and (3) potential for woodland caribou to transmit parasites and/or diseases to moose or deer at the relocation site. This initial planning effort was accompanied by considerable media publicity. The group contracted with two experienced woodland caribou biologists to survey sites in northern Minnesota as potential release sites. These biologists independently identified four sites, including the Red Lake area, (site of the last woodland caribou in the state) as potential release sites (Karns 1980). Follow-up studies revealed high deer densities with a high level of brainworm at or immediately adjacent to three of these sites, leaving only the fourth site, Little Saganaga Lake as a potential reintroduction site (Karns 1980). Identification of the Little Saganaga site was based upon the presence of summer habitat immediately southwest of the lake and winter habitat some 30 miles (50 km) south (Karns 1980).

The group proposed to secure adult caribou from Canada to develop two captive breeding herds with release of progeny from both herds to the wild. A funding request of $275,000 for the first 2 years of a 5 to 10-year project was submitted to the Minnesota State Legislature in 1980. This money was to establish facilities for the two captive herds. No funding was received from the State and the project was discontinued. Reasons for lack of funding, other than high cost, are not clear. However, concern was expressed that the public may have opposed another ''environmental initiative'' at a time Voyageurs National Park and the Boundary Waters Canoe Area Wilderness (BWCAW) of Superior National Forest had just been created (Karns 1980).

Current Planning Effort

Formation of Interagency Group

The current planning phase began in 1988 when the National Park Service contracted for an assessment of the ability of the 344 square-mile (890 km^2) Voyageurs National Park to support a viable population of woodland caribou, given current habitat conditions within the Park and adjacent areas. A contract was granted to an internationally recognized expert on caribou to apply Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service 1981) to develop a Habitat Suitability Index Model (HSI) for woodland caribou and apply it to the Park and adjacent lands. An HSI model was selected as a useful tool to summarize existing knowledge on woodland caribou habitat requirements and identify those habitat components which might limit growth of a reintroduced woodland caribou population at Voyageurs. The second phase of the contract required that, if habitat conditions were not suitable at this time, an estimate be made of whether successional trends in forest vegetation were likely to make reintroduction of woodland caribou a possibility sometime in the future. The Park simultaneously initiated studies on factors with the potential to affect woodland caribou survival, including density and distribution of white-tailed deer, incidence of brainworm in these deer and density of gray wolves. The Park communicated its actions to agencies with natural resource management responsibilities on adjacent lands, including Superior National Forest, Minnesota Department of Natural Resources, and Ontario Ministry of Natural Resources. The Superior National Forest expressed strong interest in cooperating in such an endeavor.

Subsequently, the Duluth Safari Club (not affiliated in any way with Safari Club International) informed the staff wildlife biologist for Superior National Forest that the club was interested in re-establishment of woodland caribou in Minnesota. The club offered to allocate $25,000 toward developing and implementing an introduction plan and to help raise and donate additional funds as needed to complete the project.

A caveat was added that if restoration of woodland caribou was not feasible, the balance of monies would be directed toward some worthy conservation or hunter education project.

Forest and Park biologists met with Duluth Safari Club members and agreed to form an interagency team to explore the possibilities of reintroducing woodland caribou to northern Minnesota. An interagency group consisting of five members of the Duluth Safari Club and six agency research and management biologists representing the National Park Service, U.S. Forest Service, Minnesota Department of Natural Resources, Ontario Ministry of Natural Resources and Manitoba Ministry of Natural Resources was formed. This group adopted the name, the North Central Caribou Corporation, and incorporated as a non-profit organization under state and federal laws. The Corporation created a technical advisory committee consisting of representatives of the U.S. Forest Service, U.S. Fish and Wildlife Service, Natural Resources Research Institute, University of Minnesota, Duluth, Department of Fisheries and Wildlife, University of Minnesota, St. Paul and Friends of the BWCAW. All agencies endorsed the planning process. The Minnesota Department of Natural Resources stipulated that it take the lead in making any formal request for woodland caribou to any provincial government.

In reviewing the potential of reintroducing woodland caribou, the Corporation members found reason for optimism: (1) the Ontario Ministry of Natural Resources had identified a high-density woodland caribou population as a source stock for reintroduction and acquired the technical skill for capture and movement of animals (Gladstone 1987, Bergerud and Mercer 1989), (2) the on-going reintroduction program in Maine would provide insight into the most expedient way to proceed, (3) the 1970s planning effort provided a logical starting point for this planning endeavor, and (4) creation of the BWCAW in the Superior National Forest, Minnesota, adjacent to Quetico Provincial Park, Ontario, and to a lesser extent Voyageurs National Park, Minnesota, provided large tracts of unlogged forest with the potential to support woodland caribou.

Habitat

The planning process now underway can be illustrated in a flow chart (Figure 1). The area of most suitable potential habitat remains the Little Saganaga Lake region. Woodland caribou summer habitat was identified in a 200 square-mile (520 km^2) area southwest of the lake (Karns 1980). However, the only winter habitat identified is south of the BWCAW in an area identified for logging in the Superior National Forest Management Plan. The Forest has made a commitment with representatives of the Minnesota Timber Producers Association not to reintroduce woodland caribou outside the BWCAW (E. Lindquist pers. comm. 1989). The Corporation recognizes the need to evaluate habitat conditions beyond the target release site to assess the possibility of caribou moving into areas of potential conflict with current or proposes land use practices, or where they might encounter white-tailed deer. Recently, Bergerud and Mercer (1989) defined the scope of the Corporation's assessment of habitat by recommending a minimum release area of greater than 2,510 square-miles (6,500 km^2). The reintroduction program in Maine is targeted at the 200 square-mile (518 km^2) Baxter State Park (M. McCollough pers. comm. 1990). The Corporation currently proposes to take the HEP results provided under contract for Voyageurs National Park and map these using a geographic information system for the 115

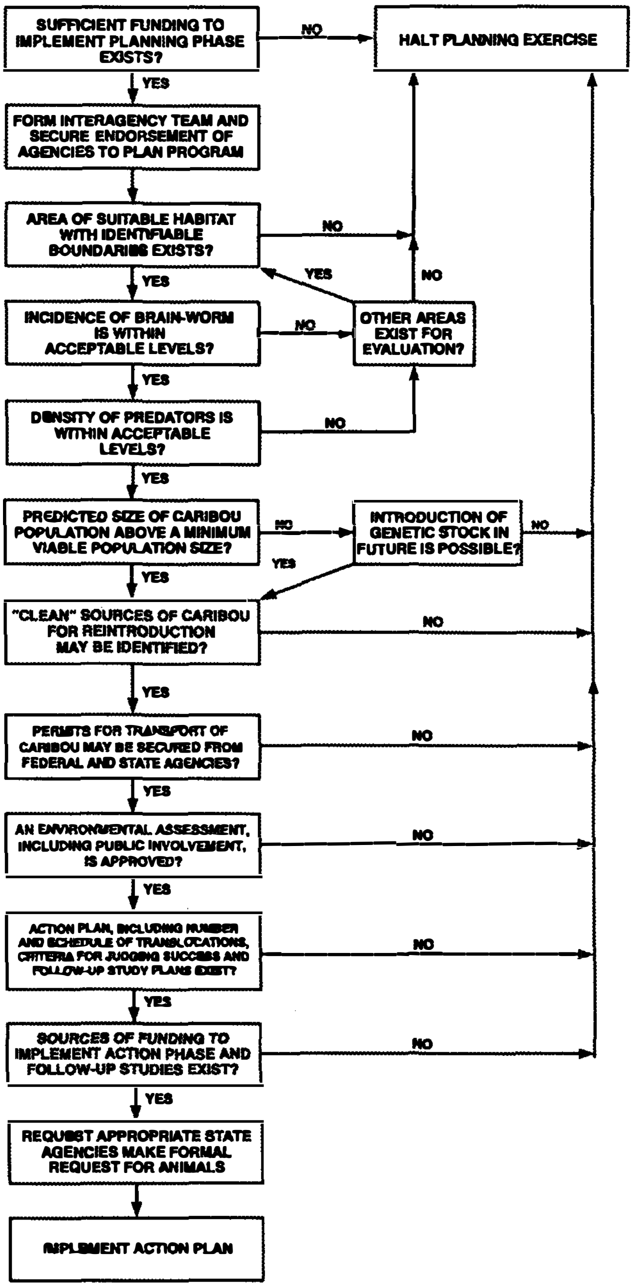

Figure 1. Flow chart for planning woodland caribou reintroduction to Minnesota.

square-mile (295 km^2) portion of the Park for which a detailed vegetative cover map exists. The results are expected to provide an assessment of the abundance, heterogeneity and distribution of seasonal habitat requirements. Should this pilot survey prove feasible, the Corporation will apply the methodology to the Little Saganaga Lake area, using less detailed vegetative cover information. The total costs of this phase of the study are estimated to be in excess of $70,000. This figure includes the Park's cost for development of the HEP, a U.S. Forest Service Challenge Grant Request, and donated time by the Natural Resources Research Institute, University of Minnesota, Duluth.

Predation

It appears that woodland caribou will not survive in areas where wolf density exceeds one per 40 square miles (104 km^2) (Bergerud 1985). The wolf density in the vicinity of Little Saganaga Lake is approximately one per 20 square miles (52 km^2) (L.D. Mech pers. comm. 1989). The Corporation has provided a modest amount of money to facilitate more detailed studies of seasonal movements of wolves in the Little Saganaga Lake area.

A number of successful reintroductions of woodland caribou were made to sites in Newfoundland where black bear (*Ursus americanus*) were potential predators (Bergerud and Mercer 1989). However, predation by black bear has been identified as an important cause of mortality in woodland caribou released in northern Maine in 1989 (M. McCollough, pers. comm. 1990). The Corporation has requested an estimate of black bear density in the vicinity of Little Saganaga Lake from a U.S. Forest Service biologist.

Parasitism

White-tailed deer are the normal definitive final host for the meningeal brainworm parasite. Infection of woodland caribou with this parasite is generally fatal (Anderson and Strelive 1968, Anderson 1971). Reintroductions of woodland caribou to areas occupied by white-tailed deer have frequently failed, and infection of caribou with brainworm has been identified or implicated as the cause of the failure (Bergerud and Mercer 1989). The high risk of infection of woodland caribou by this parasite resulted in rejection of three of four potential release sites for woodland caribou identified on the basis of habitat conditions (Karns 1980). A survey of the Little Saganaga Lake area in 1977 revealed an incidence of brainworm in deer fecal samples of 5.0 percent (Karns 1980). A second survey of a 50 square-mile (130 km^2) area around Little Saganaga Lake in summer 1989, jointly funded by the North Central Caribou Corporation and the University of Minnesota, revealed none of the gastropod snails (intermediate hosts) and only one of four deer pellet groups located contained brainworm larvae (Jordan and Pitt 1989). Long-term studies of white-tailed deer in northern Minnesota show that deer concentrate at winter yards near the communities of Ely and Isabella, and in the Gunflint Region and range some 16 miles (26 km) from these yards in summer (M. E. Nelson pers. comm 1989). While the Little Saganaga Lake area is beyond the range of most deer using these yards, the summer distribution of white-tailed deer represents the limits of areas that might be reasonably expected to support woodland caribou. The frequency of brainworm in wintering whitetails in the Gunflint and Isabella yards was 44 and 60 percent, respectively (Jordan and Pitt 1989).

Free-ranging woodland caribou in Newfoundland have been infected with a Eurasian reindeer parasite, *Elaphostronglylus cervi rangiferi*, as the result of introduction of reindeer. Experimental infestations of moose with *E. cervi* caused pathological changes and paralysis (Lankester 1976). An *E. cervi*-like parasite had been tentatively identified in woodland caribou in Ontario (Lankester et al. 1976, Lankester and Northcott 1979, Gray and Samuel 1986). The reintroduction of woodland caribou infected with this parasite to northern Minnesota could have serious implications for the State's moose population. Recently, the *E. cervi*-like parasite has been positively identified as a muscle worm (*Parelaphostronglylus andersoni*) (Lankester and Hauta 1989). It is common to white-tailed deer across North America (Anderson and Prestwood 1981, Pybus and Samuel 1984) and woodland caribou in Labrador and Ontario (Lankester and Hauta 1989) without apparent detriment to either ungulate species.

Minimum Viable Population Size

The minimum area of 2,510 square miles (6,500 km^2) recommended by Bergerud and Mercer (1989) may be achieved in the Little Saganaga Lake region by identifying potential habitat within the BWCAW and Quetico Provincial Park. The density of woodland caribou in Ontario ranges from 0.016 per square mile (0.006/km^2), (Cumming and Beange 1987) to 0.05 per square mile (0.02/km^2) (Darby et al. 1989). An area of 2,510 square miles (6,500 km^2) may be expected to support between 40 and 130 woodland caribou. A remnant, somewhat isolated group of 15–30 woodland caribou has occupied a three-mile (5 km) wide strip of Lake Superior shoreline at Pukaskwa National Park, Ontario, since 1972 (Bergerud 1985), indicating such populations may persist for some 20 years. Small populations may become extinct as the result of a number of stochastic population factors, including inbreeding depression, genetic drift or shifts in sex ratio (Gilpin and Soulé 1986). A minimum effective population size of 50–500 individuals may be considered adequate to prevent a loss of population fitness due to inbreeding depression (Franklin 1980). It is possible to reduce concerns for inbreeding depression and genetic drift by introducing new individuals to the newly-established population once every five years (Sampson et al. 1985).

Translocation Plan

The translocation objective is to deliver as many animals with the greatest chance of survival to the release site. Three possible methods are being considered: (1) direct translocation of woodland caribou from Slate Islands Provincial Park, Ontario, (2) establishing a nursery herd from wild-caught or captive woodland caribou away from the release site and releasing the progency to the wild as they approach sexual maturity (two to three years old), or (3) hand-rearing calves at the release site through their first summer and releasing them to become free-ranging in the fall. A combination of these alternatives may be used. Movement of animals across international or state boundaries will require permits from the USDA's Animal and Plant Health Inspection Service (APHIS), including tests for brucellosis and tuberculosis, along with permits from appropriate state agencies.

The Ontario Ministry of Natural Resources has acquired considerable expertise in the capture and handling of woodland caribou. Ministry personnel have made five direct translocations to four sites in or adjacent to Lake Superior since 1982 (H. R.

Timmerman pers. comm. 1989). Optimal timing for a translocation of adults may be after the fall rut. Adult females are then in peak physical condition and have been recently impregnated. The good physical condition of females and subadult males, which did not participate in the rut, make them ideal candidates for translocation at that time (W. J. Dalton pers. comm. 1989). Translocations of woodland caribou directly to predicted winter habitat may favor the establishment of a winter aggregation (Cumming and Beange 1985).

The advantage of use of a nursery herd is that number of animals reintroduced may exceed by several fold the number taken from the wild. This method has been used extensively with woodland caribou (Bergerud and Mercer 1989). The woodland caribou released to Baxter State Park, Maine in 1989 were from a nursery herd (M. McCollough pers. comm.). Hand-reared barren ground caribou calves (*R. t. granti*) have been used to successfully establish a herd, although mortality among calves approached 70 percent (Jones 1966).

Other Considerations

The Corporation has yet to address many other facets of the planning exercise. It is envisioned that public involvement will be assured through review, including public hearings, of the Environmental Assessment that will be prepared prior to management actions on Federal lands. To date, the Corporation has not sought public attention or solicited funds from the public. It intends to initiate a fund-raising campaign coincident with publicity generated by the first translocation of woodland caribou to Minnesota. The Corporation will develop a detailed action plan which will cover the number and schedule of reintroductions and contingency plans to respond to undesirable events, such as individual woodland caribou moving outside the envisioned release site. Criteria for evaluating the success of the program must also be set forth in detail. Finally, a reintroduction, such as that detailed here, provides an opportunity for experimental management (Sinclair 1979, Houston 1982) with the hypotheses to be tested and criteria under which the hypotheses are to be evaluated set forth before the reintroduction is initiated. Planning and budgeting for detailed follow-up study must be in place prior to releasing any animals to the wild.

Summary

The possibility of reintroducing woodland caribou to northern Minnesota has intrigued sportsman's groups, environmentalists and professional wildlife biologists since the species extirpation in the 1940s. A planning effort in the 1970s was not completed nor implemented because of lack of public funds. Planning was begun again in the late 1980s. This latter effort involves extensive interagency cooperation. It builds upon the work of the initial planning group. Many issues remain to be resolved before a reintroduction can be contemplated.

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Genetic Considerations in the Design of Introduction Programs

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Introduction

Historically, little concern has been given to effects of introduction and reintroduction programs on patterns and levels of genetic variation in wildlife species. However, genetic variation can influence the physical attributes of individuals, as well as the short- and long-term success of introduced populations. My objective is to discuss some of the genetic considerations in the design of introduction and reintroduction programs. These include: loss of genetic variation in introduced populations and ways to minimize this loss, selection of source populations, selection of individuals to be released, effects of mixing individuals from different populations and use of individuals from captive populations in introductions. I also suggest ways to use genetic variation to enhance the success of introduced populations.

Loss of Genetic Variation in Introduced Populations

There are two basic measures of genetic variation in natural populations (Allendorf and Ryman 1987, Meffe 1987). The most common measure is the average proportion of loci for which an individual is heterozygous (mean heterozygosity). An individual is heterozygous for a locus (or gene) when it has received a different allele from each of its parents. Heterozygosity decreases as individuals become more inbred. A second useful measure of genetic variation is the diversity of different alleles in the population. One index of allelic diversity is the mean number of alleles per locus. These two measures are related (two different alleles are needed to form a heterozygous genotype), but have different management implications.

We should be concerned about effects of management activities on loss of heterozygosity because it can affect the short-term success of introduced populations. A large body of literature suggests that individuals that have lost heterozygosity due to inbreeding have depressed growth, reproduction, and survival (i.e., Templeton and Read 1983, Ralls et al. 1988). Studies of wild populations also suggest that individuals heterozygous at one or more loci have higher growth, fecundity and survival rates than individuals that are less heterozygous for the same loci (i.e., Allendorf and Leary 1986). Furthermore, a laboratory experiment has shown that fish from a population with high mean heterozygosity had higher values of these same fitness traits than fish from populations with low levels of heterozygosity (Quattro and Vrijenhoek 1989). Although the mechanism responsible for the relationship between heterozygosity-fitness traits is currently being debated (Leberg et al. 1990), management implications of these studies are clear. Practices that result in decreased heterozygosity and increased inbreeding can affect growth, survival and fecundity of the individuals being managed. Because these fitness traits are related directly to the success of populations, those comprised of genetically variable or outbred individuals are expected to have higher growth and lower extinction rates than populations comprised of less variable or more inbred individuals. Until studies of effects of genetic variation on the function of wildlife populations are conducted, it is prudent to assume that genetic variation is important to the short-term success of introduced populations (Meffe 1987).

Physical attributes of wildlife species that are of interest to managers and sportsmen can also be affected by heterozygosity. Individuals that have lower levels of heterozygosity may have lower growth rates and may not develop normally. In the white-tailed deer (*Odocoileus virginianus*), less heterozygous individuals have smaller, less symmetric antlers than their more heterozygous counterparts (Scribner et al. 1989, Smith et al. in press). Similarly, weight, spur length and beard length of wild turkeys (*Meleagris gallopavo*) decrease with reduced heterozygosity (P. L. Leberg and P. W. Strangel unpublished data). If one objective of an introduction program is to produce individuals of trophy quality, high levels of heterozygosity should be maintained.

Allelic diversity affects the ability of a population to adapt to new environmental conditions (Allendorf and Ryman 1987). Without genetic variation, in the form of different alleles, the ability of a population to respond to new selective pressures is limited. If the long-term success of a population is important, such as in the case of an endangered species, steps should be taken to prevent loss of allelic diveristy.

Introduced populations will have reduced levels of genetic variation if they are established using individuals that do not contain most of the variation present in their original population. This loss, due to incomplete inclusion of the available genetic variation when the population is established, is random with regard to what genotypes and alleles are retained in the population. The loss of genetic variation within populations increases differences among populations. Divergence occurs because different populations obtain different alleles from their respective founders. Both of these processes have probably occurred with the reintroduction of white-tailed deer and the wild turkey in the eastern United States (Hillestad 1970, Leberg submitted, Leberg in preparation). In both species, the average number of loci for which individuals are heterozygous is 25–30 percent smaller in introduced populations than in native populations (but *see* Turk and Romano submitted). Furthermore, the amount of genetic divergence among native populations of turkeys is approximately four times less than the amount among introduced populations.

If the number of founders is small, there is a high probability that matings between closely related individuals will occur in the first several generations after the introduction. In the extreme case, if only one male and one female establish a new population, all individuals in the next generation would be siblings. Matings between siblings can result in severe inbreeding depression (Ralls and Ballou 1983).

In many cases it may not be easy to distinguish causes from effects of relationships between genetic variability and success of populations. The rate of loss of genetic variation of new populations is affected by its growth rate. A slowly growing population loses more genetic variation than one that grows rapidly (Nei et al. 1975). Reduced genetic variation can potentially decrease growth rates of populations because inbreeding depresses both fecundity and survival rates. Higher growth rates of populations may also decrease extinction rates, decreasing losses of alleles which are unique to single populations. These relationships between genetic variation and population growth rate suggest that most actions taken to increase either factor will affect both. With planning it should be possible to develop a management strategy that is compatible with both demographic and genetic considerations.

Minimizing Losses of Variation in Introduced Populations

The loss of genetic variation and the likelihood of close inbreeding is influenced by the number of released individuals that successfully reproduce (founders) and by their demographic and genetic composition. There is a direct relationship between the amount of genetic variation retained in a new population and the number of founders. An estimate of the proportion of heterozygosity of the original population (source from which the founders are obtained, H_s) that is retained in the introduced population is:

$$H_s \times [1 - \frac{1}{2 \times N}] ; \qquad (1)$$

where N is the number of individuals founding the population (Wright 1969). When the number of founders is small, loss of heterozygosity is large; however, founding population sizes of 10 or more individuals can retain most (≥ 95 percent) of the heterozygosity found in the source population (Figure 1).

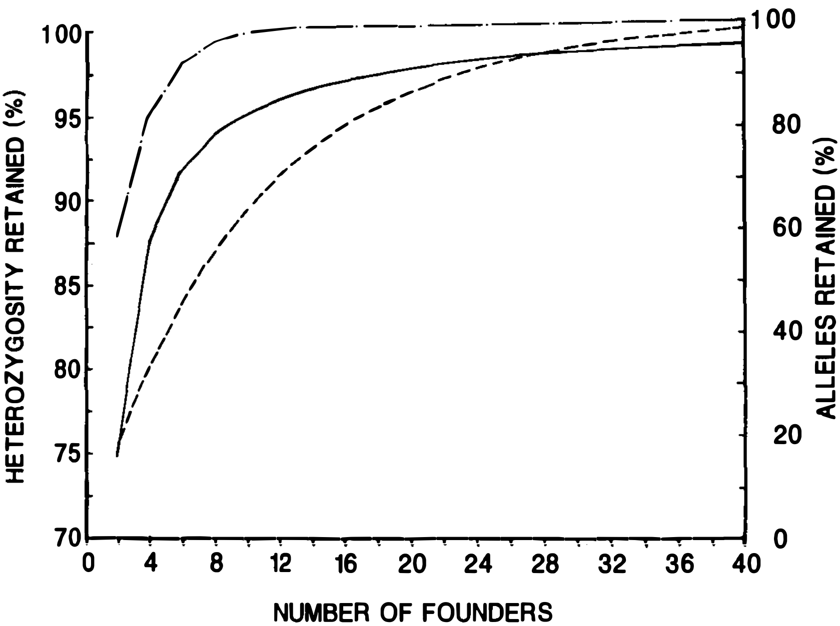

Figure 1. Effects of the number of individuals founding a population on the percentage of original heterozygosity (solid line), and alleles retained (dashed lines) in the introduced population. The unevenly dashed line represents the percentage of five equally frequent (frequency of 0.20) alleles retained in the introduced population; the evenly dashed line in the percentage of 20 equally frequent (frequency of 0.05) alleles that is retained.

Reductions of heterozygosity as small as 6 percent have resulted in reductions in the performance of individuals (Ralls and Ballou 1983). This suggests that populations founded by fewer than 10 individuals might suffer from immediate negative effects of inbreeding depression and loss of heterozygosity. However, it is not easy to predict the minimum number of founders necessary to avoid inbreeding depression because species differ greatly in tolerance to inbreeding depression (Ralls et al. 1988).

Estimates of losses of heterozygosity obtained in Equation 1 can be influenced by several factors (Wright 1969, Ryman et al. 1981). For instance, the number of founders is not necessarily the same as the number of individuals released. The latter might be much larger than the former because many individuals may migrate from the release site or die before they contribute offspring to the next generation. The number of individuals released must take into account post-release dispersal and mortality.

The variance in the reproductive success of founding individuals can influence the amount of heterozygosity retained in the population. Because overlapping generations tend to reduce this variance, introductions of species with overlapping generations will lose slightly less heterozygosity than predicted by equation 1. If there is much variation in the success of founders in contributing offspring to the next generation, equation 1 will underestimate the loss of genetic variation. This can be important in polygamous species because only a few of the males in the population might successfully father offspring. Genetic variation in the unsuccessful males is lost. A similar loss of genetic variation can occur when managers release more females than males. Data on releases of wild turkeys suggests that two to four hens are released for every male (National Wild Turkey Federation 1986). Given the same total number of founders, a population founded with equal numbers of both sexes will retain more genetic variation than one founded with more of one sex than the other. This loss occurs in a population with unequal sex ratios because the average genetic contribution of each member of the rarer sex to the next generation is larger than the average contribution of each member of the more common sex. Consider a population established with one male and two females. One half of the next generation's genome is contributed by the male, where as each female contributes only 25 percent.

Equation 1 can be modified to estimate the amount of genetic variation retained in an introduced population founded by unequal numbers of males and females (rearranged from Wright 1969). The proportion of heterozygosity in the source population (H_s) that is retained in the introduced population is:

$$H_s \times (1 - \frac{N_f + N_m}{8 \times N_f \times N_m}) ; \qquad (2)$$

where N_f is the number of females and N_m is the number of males that found the new population. The closer the sex ratio of the population's founders is to 1:1, the lower the loss of heterozygosity (Figure 2). Losses due to unequal sex ratios are greatest when the number of founders is small. In general, when only a few individuals can be released, equal numbers of both sexes should be used. However, if the release of different numbers of each sex is unavoidable, or if it is desirable because the species is highly polygamous, the number of individuals released should be increased (i.e., a population founded by 3 males and 12 females loses the same amount of heterozygosity as one founded by 5 males and 5 females).

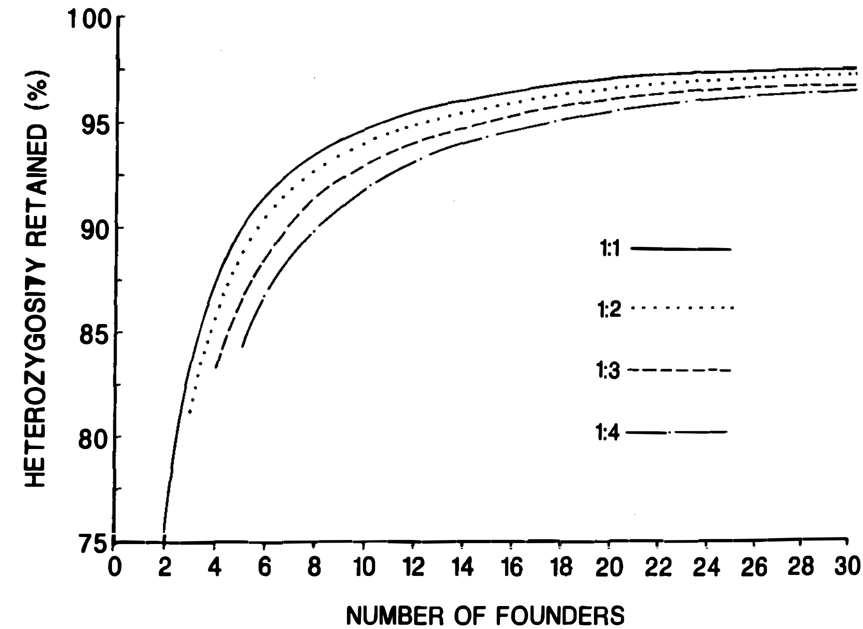

Figure 2. Effect of different sex ratios on percentage of heterozygosity retained in the introduced population.

Relatedness among founders of a population can also have large effects on the amount of genetic variation that is lost. The higher the relatedness among founders, the higher the loss of genetic variation. Release of potentially related individuals has been encouraged in some restoration programs. For instance, release of turkeys from the same flock (Schorger 1966) was considered to be an effective way to reduce dispersal from the release site. However, release of related individuals results in the first generation of offspring in a new population being more inbred than if the population was established by unrelated individuals. Two half-siblings contain only 87.5 percent of the heterozygosity present in two unrelated individuals; siblings contain only 75 percent of the heterozygosity of unrelated individuals. The limited dispersal and social organization of most wildlife species leads to increased genetic similarity or relatedness among spatially proximate individuals (Smith et al. 1976). When possible, family groups or other potentially related individuals (such as those captured together or at the same site) should not be released together. If the release of related individuals is desirable or unavoidable, individuals representing several different families of trapping sites should be released and the number of founders should be increased.

There are also formulas available to estimate the loss of alleles for different numbers of founders (Denniston 1978). These estimated loses of alleles are affected by all the factors affecting the loss of heterozygosity. For the simple case of a random mating population with equal sex ratios and nonoverlapping generations, the loss of allelic diversity can still be great for founder sizes large enough to retain most of the heterozygosity in the source population (Figure 1). Losses of alleles present in low frequencies are considerably greater than those of more common alleles (Figure 1). One approach to preserving allelic diversity is to use as many founders as possible to establish a new population. Allendorf and Ryman (1987) recommend that populations of fish be established with 50 founders to preserve allelic diversity. In many introduction programs, it may not be possible to establish populations with releases of this size. An alternative approach to the release of a large number of founders is to create many semi-isolated populations, each founded with only a few individuals (Chesser et al. 1980). Some alleles are lost within each population, but by creating a large number of populations it is likely that each allele is preserved in at least one or more of them. Although this strategy has several other benefits (e.g., it is unlikely that any one natural disaster would wipe out all of the populations), its success is based on the premise that most separate populations survive. Therefore, each population should still be founded by enough individuals to avoid effects of inbreeding and loss of heterozygosity on short-term viability.

Selection of Populations as Sources of Founders

Differences in physical or life-history traits are often observed among populations. If these differences have a genetic basis, selection of a source of founders can affect the appearance and ecology of individuals in the introduced populations. Sources of founders could be selected on the basis of the occurrence of specific traits. For example, white-tailed deer in the Midwest tend to have larger antler sizes than do deer in the Southeast. For antler size, deer from southeastern populations established with individuals from the Midwest were physically more similar to deer from the Midwest than to deer from native southeastern populations (Marchinton et al. in press). In laboratory studies, choice of source population has been shown to influence many ecological traits (i.e., Wade 1979). Therefore, it may be possible for managers to influence population-level traits in introduction programs. Unfortunately, it is usually not known if differences in physical or ecological performance of potential source populations are due to genetic differences or to differences in environmental conditions such as habitat quality (Marchinton et al. in press).

It is likely that some genetic differences among populations are due to adaptations to local conditions. Therefore, caution should be used in the selection of source populations on the basis of specific traits because these traits might be maladaptive in the environment of the release site. Individuals released to found new populations should be obtained from habitat similar to that of the intended release site (Smith et al. 1976).

The selection of a source population should also be based on its level of genetic variation. The level of genetic variation in an introduced population is influenced partially by the level of genetic variation in the source population. Protein electrophoresis is the most common method of measuring levels of genetic variation among field populations (Smith et al. 1976); however, other methods involving DNA restriction analyses are becoming available. In captive populations, breeding experiments can be used to estimate genetic variation for quantitative traits such as body weight or antler size. All of these techniques have the disadvantage of estimating total genetic variation from variation present in only a few genes; however, this is usually the only type of information available. Historical data can also be used to estimate relative levels of genetic variation of potential source populations. For example, the wild turkey population in the state of Kentucky was at one time reduced to seven individuals (R. D. Smith pers. comm. 1981). Because genetic variation was undoubtedly lost during this reduction in population size, populations of turkeys that remained large probably contain more genetic variation than the Kentucky population.

There may be some disadvantages in choosing the most genetically variable populations as the sources of individuals to be released in an introduction program. The history of the population from which released individuals are obtained can greatly influence their susceptibility to inbreeding depression. If a population has experienced high levels of inbreeding in the past, many deleterious alleles responsible for inbreeding depression may have been lost due to selection (Templeton and Read 1983). Therefore, exposing this population to additional inbreeding would not result in serious inbreeding depression. Selection of a source population with higher levels of genetic variation would increase the level of genetic variation in the introduced population, but it might also result in high levels of inbreeding depression. This observation suggests that a population with low heterozygosity might be the best source of founders because they may be less susceptible to inbreeding depression. However, except in cases where inbreeding is expected to be very high (i.e., fewer than six founders are available), the long-term benefits of high levels of genetic variation probably outweigh any of the temporary effects of inbreeding depression.

In the case of an endangered or threatened species, separate populations should probably be established with individuals from each native population that contain unique genetic material. If a native population goes extinct, its unique alleles are also lost. The establishment of several introduced populations, each founded with individuals from a different population, would preserve more genetic variation than if individuals from only one source were used to establish all of the introduced populations.

Mixing of Different Populations

An obvious way to increase genetic variation is to mate individuals from genetically different populations. Releasing individuals from several different populations together might result in a vigorous hybrid population with a high level of genetic variation. Experimental populations of fish founded from two sources had higher fecundity rates than populations founded from one source (Leberg unpublished data). Wild turkey populations founded by individuals from several populations have higher levels of heterozygosity than populations from which the founders were obtained (Turk and Ramano submitted). The release of individuals from a different population has also been used to enhance genetic variation within a native population of turkeys; the release apparently lead to increased reproductive performance (R. D. Smith pers. comm. 1981). However, this approach should be used with caution. Some crosses between genetically different populations produce offspring with reduced growth, survival and fecundity (Templeton 1986). This reduction in vigor, or "outbreeding depression," is believed to occur when combinations of genes that function well together in a population are disrupted due to matings with individuals from other populations without the same gene combinations. Much less is known about outbreeding depression than inbreeding depression. It is very difficult to know what crosses will produce vigorous individuals, and which will hve undesirable effects. It is also believed that effects of outbreeding depression are temporary in terms of evolutionary time. If the introduced population survives the first few generations of outbreeding depression, the effects are likely to disappear (Templeton 1986).

Unless experiments examining fitness of offspring (and their offspring) resulting from matings of individuals from different populations have been conducted, it is prudent to avoid releasing individuals from populations with markedly different genetic backgrounds. If it is necessary or desirable to release individuals from different populations together, a large number of individuals should be released, so the population does not go extinct during the first several generations from the effects of outbreeding depression on reproduction or survival. A genetic survey of the species of interest using protein electrophoresis or one of the DNA restriction techniques may be useful in identifying populations with different genetic characteristics. In the absence of this information, it is probably best to avoid crossing populations that differ in morphology, such as many recognized subspecies. These differences may reflect the underlying genetic structure of the species (although this is not always the case).

In addition to preventing outbreeding depression, there are other reasons to avoid crossing genetically different populations. Many populations have adaptions to local conditions. In the unlikely situation that the number of individuals released is large relative to the native population, these adaptions could be lost. More likely, the mixing of populations through introductions will tend to decrease genetic differences among them. Differences among populations, such as those observed among subspecies, are valued by many individuals (sportsmen, bird watchers, biologists, etc.), and actions that would result in their loss should not be undertaken lightly.

Selection of Individual Founders

It is best not to select individuals as founders of a population based on specific traits, such as body weight or antler size. This type of choice represents a form of selection and could lead to loss of genetic variation at the loci affecting the trait of interest. Additional variation is lost at the many loci located on the chromosomes near the loci affecting the trait. A study of the effects of different criteria used to select individuals to establish a population of Guam rails (*Rallus owstoni*) suggested that selecting founders based on fecundity or even individual heterozygosity (as measured by electrophoresis) led to greater losses of genetic variation in the introduced population than did random selection of founders (Haig et al. 1990). Reduction in genetic variation resulting from selection for the most heterozygous individuals to establish a population occurred because most rails with high allozyme heterozygosity in the captive population were from the same family.

If pedigree information is available for captive individuals, it can be used to help select individuals to found wild populations with the highest possible levels of genetic variation. To maximize genetic variation in the new population, approximately equal amounts of the genetic material of each of the original founders in the captive population should be present in individuals chosen to establish the new population [*see* Haig et al. (1990) for details].

Use of Founders from Captive Populations

Use of individuals from game farms, hatcheries and other captive breeding facilities in introduction programs is common for some species. All considerations concerning genetic variation in introduced wild populations apply to establishment of the captive populations. It is illogical to design introduction programs to maintain high levels of genetic variation if all genetic variation in the captive population supplying the founding individuals was lost when it was established. Captive populations should be established with as many unrelated individuals as possible.

There are disadvantages in removing organisms from their natural environment and placing them into captivity where selective pressures are different. Genotypes that might do well in nature might fare poorly in captivity. Alternatively, genotypes that might normally not be viable, may prosper under human protection in captive rearing facilities. Traits associated with tameness are also selected for in captive populations. Individuals with adaptations to captivity may not fare well when released in the wild. For example, turkeys from game frms have been relatively unsuccessful in establishing wild populations (Schorger 1966). The best way to avoid effects of selection is to keep populations in captivity for the smallest number of generations possible. Additionally, individuals from wild populations should be introduced into the captive population at frequent intervals.

Management and Research Recommendations

Managers should design restoration programs to avoid loss of genetic variation in newly established populations. Prior to initiation of an introduction program, as much information as possible regarding the history, ecology and genetics of populations that are potential sources of founders should be obtained. Genetic variation within introduced populations is best maintained by releasing as many unrelated individuals of both sexes as is possible. Founders should be obtained from a population with a high level of genetic variation. Additional allelic variation can be preserved by establishing several introduced populations. Introduction strategies that select founders based on some trait, depend on the use of captive stock or result in mixing of different populations should be pursued cautiously. However, these recommendations are subject to modification to the specific management situation. Because differences in the biology of species affect the loss of genetic variation in founder events and the response to inbreeding and outbreeding, it is not possible to provide more specific recommendations. One approach to deal with this problem is to use a simulation model that incorporates important aspects of the species biology to evaluate the effects of different management practices on genetic variation and population performance (for related examples *see* Ryman et al. 1981, Haig et al. 1990).

Use of genetics in wildlife management is in its infancy and many important, basic questions need to be answered. How important are inbreeding, outbreeding and genetic variation to the short- and long-term success of wildlife populations? Are there optimal levels of inbreeding and outbreeding, and how do they differ between species? Can theoretical models from population genetics be modified to predict accurately the loss of genetic variation resulting from management practices? It is not clear which genetic issues are most important in the management of wild populations because most work in this area has been done in agricultural and laboratory settings. Introduction programs could be designed as experiments to test hypotheses concerning management and genetics under field conditions, while still achieving specific managament objectives. It would serve both managers and researchers well to work together to use introductions to answer questions important to both population biology and wildlife management.

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Biological Criteria for Introductions of Large Mammals: Using Simulation Models to Predict Impacts of Competition

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Introduction

The current abundance of many important species of wildlife in North America can be traced to successful programs of introduction and/or reintroduction. Outstanding examples include Rocky Mountain elk (*Cervus elephus nelsoni*) ring-necked pheasants (*Phasianus colchicus*), and rainbow trout (*Salmo gairdneri*), species that collectively provide enormous recreational opportunity to the citizens of this continent. In retrospect, it is clear that benefits offered by these species have exceeded their environmental costs. However, in prospect, it is often uncertain whether the value gained by transplanting animals will outweigh the harm done. There are many examples of introductions gone bad, for example European starlings (*Sturnus vulgaris*), common carp (*Cyprinus carpio*) and cheatgrass brome (*Bromus tectorum*). Remembering these failures underscores our obligation to examine carefully the potential impacts of adding a species to existing communities of plants and animals.

Here, we consider ways that information can be focused on the problem of introducing animals into habitats from which they have been absent. In particular, we describe the use of simulation models to examine potential impacts of introductions on competitive interactions among species, and to plan actions to influence the outcomes of those interactions. Although we use ungulates as an example, our approach is substantially general and should provide application to a variety of birds and mammals.

Problem Description

There are many reasons to introduce a new species to an ecosystem. Introductions may improve human access to wildlife, increase the probability of survival of endangered animals, enhance community diversity, or contribute to reduction of pests through predation or competition. However, introducing an animal species to a new habitat does not occur without risk. Many ecologists believe animal communities exist at equilibrium with habitat resources limiting population growth of individual species (reviewed by Schoener 1982, 1983, but also Wiens 1977, Huston 1979, Connor and Simberloff 1986). It follows that adding species to an existing fauna may upset equilibria among animal populations and increase the likelihood of local extinctions via competition. To the extent that competition influences growth of animal populations, introductions may harm desirable species that suffer a competitive disadvantage with those that are introduced. In planning introductions, we must foresee the tradeoffs between benefits and costs of such actions and design management interventions to capitalize on their benefits while minimizing their costs.

Example Application

We recently used simulation modeling to evaluate the biological benefits and costs of translocating mountain goats (*Oreamnos americanus*) within Colorado, and to formulate criteria for deciding when such translocations would be appropriate. We believe our specific application illustrates a broadly useful approach in planning introductions.

Policy Context

It is not certain whether mountain goats were ever indigenous to Colorado. Some workers hypothesize that mountain goats ranged in the southern Rocky Mountains as recently as the Wisconsin glaciation and that their disappearance coincided with large-scale loss of alpine tundra habitats (Hibbard 1958, Hoffmann and Taber 1967). There are reports of mountain goats in Colorado as late as 1897, but these are questionable (Feltner 1972, Rutherford 1980). Regardless, it is fairly certain that mountain goats were absent from Colorado from the early 1900s until the period 1948–1971, when they were successfully introduced (Rideout and Hoffmann 1975, Denney 1977).

Over the last 15 years, policy of the Colorado Division of Wildlife has prevented additional translocations of mountain goats because it was widely believed they compete with native populations of mountain sheep (*Ovis canadensis*) for limited areas of suitable high elevation habitat. Mountain sheep populations have performed poorly in many areas of Colorado (Wakelyn 1987, Risenhoover et al. 1988), and hence it seemed wise to avoid actions that might further restrict their distribution and abundance. However, policy discouraging introductions of mountain goats may unduly limit choices for managing alpine ungulates. It may be possible to successfully manage introduced populations of mountain goats such that they do little or no harm to mountain sheep.

Objectives

We analyzed policy alternatives for managing sympatric populations of mountain goats and mountain sheep using a model simulating the dynamics of their populations in an alpine ecosystem. The objectives of our analyses included: (1) predicting the probable risks to mountain sheep populations resulting from reinitiating translocations of mountain goats, (2) developing translocation guidelines that would minimize those risks, and (3) suggesting research and monitoring that would enhance future management capabilities.

Model Context

We examined the consequences of introducing mountain goats into alpine habitats occupied by mountain sheep. Although this is clearly not the only policy option for managing sheep and goats (for example, goat transplants could occur where sheep are not found currently), we believed it was the choice that had to be examined. This was the case because any introduction of mountain goats into Colorado, regardless of its location, increases the likelihood that dispersing, introduced mountain goats will compete with resident, indigenous mountain sheep. Moreover, such introductions also may limit future locations for mountain sheep transplants if the question of competition remains unresolved. Thus, although transplanting mountain goats to mountain sheep ranges represents an extreme management tactic, it also offers the strongest test of the viability of establishing new mountain goat populations in the state. We wanted to simulate "worst case" conditions.

The model was constructed to represent interactions of mountain sheep and mountain goat populations on alpine grasslands in the central Rocky Mountains. We assumed that modeled populations traversed 40 km^2, of which 20 km^2 were used intensively. Within this area there were two distinct habitat types, cliffs and meadows. We chose to simulate a hypothetical area rather than an actual location to enhance the generality of our model, and to allow us to draw on data from different geographic locations.

Model Description

Our model was structured as Leslie matrix for two sexes and 12 annual cohorts of two populations (Figure 1). Vectors for survivorship and natality were modified at a yearly time step in response to simulated environmental conditions. Model behavior was governed by several key assumptions. (The computer code implementing these assumptions can be obtained by writing to the senior author).

The model represented mountain sheep and mountain goat populations using alpine and subalpine habitats above 2,700 m. We assumed that sheep and goat populations used different alpine terrain: mountain goats reside most frequently on steep cliffs and ridges (McFetridge 1977, Thompson 1980, Schoen and Kirchoff 1981, Chadwick 1983, D. F. Reed unpublished data), while mountain sheep use adjacent grasslands of lower slope (Geist 1971, D. F. Reed unpublished data). However, a pivotal assumption of the model was that mountain goats disperse into meadows as their populations increase in density, but that sheep will not use cliffs. It appears that in the absence of pressure from predators, distribution of mountain goats is not limited to steep terrain (Chadwick 1983:83). Thus, we assumed spatial mechanisms of ecological separation seen in northern ranges were not strongly operative in Colorado. Moreover, we assumed that mountain sheep were sedentary and did not migrate to lower elevations to avoid competition with goats.

We further assumed that competition between mountain goats and mountain sheep acts to depress growth of both populations. Population growth rates in the model were regulated by natality, natural mortality, harvest and dispersal. Interactions between simulated mountain goats and mountain sheep that impaired their ability to

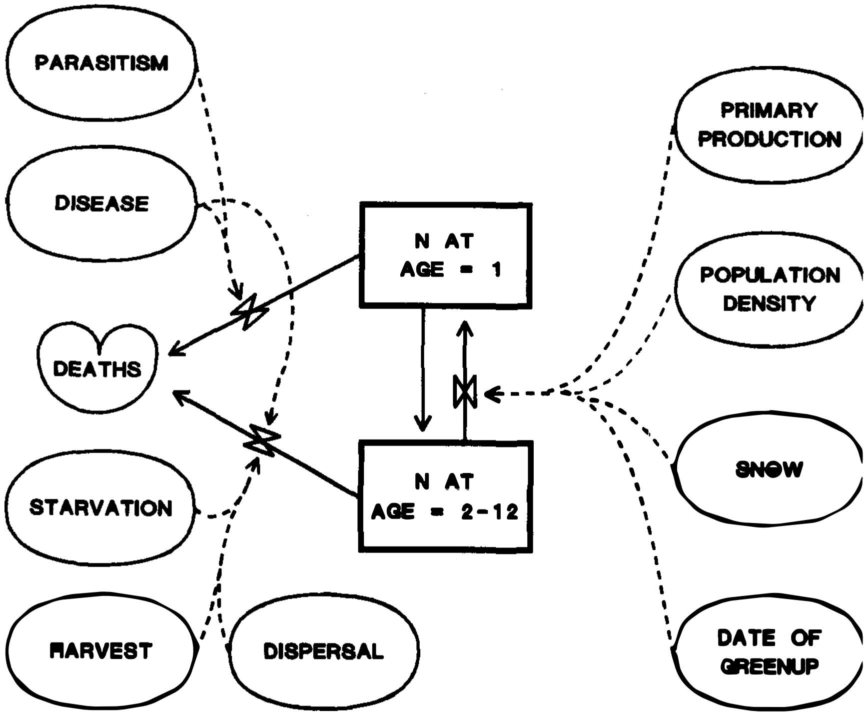

Figure 1. Age-structured population dynamics model representing births and deaths of mountain sheep and mountain goats. Natality is indicated by flow from the lower box to the upper one. In both species, the number of animals added to the population is controlled by per capita availability of winter food and date of spring green-up. Mortality in mountain goats is controlled by starvation, dispersal and harvest; dispersal adds to effects of mortality on goat numbers. Mortality in mountain sheep is controlled by epidemic disease, parasitism, starvation and harvest.

obtain high quality forage in sufficient amounts lowered their nutritional status. For both species, undernutrition reduced the number of surviving offspring produced in spring and elevated rates of over-winter mortality in juveniles and adults (Nichols 1980, Jorgenson and Wishart 1986, Smith 1986). However, because mountain goats have food habits that are more catholic than those of mountain sheep (Adams and Bailey 1983, Dailey et al. 1984), we assumed that goats are less sensitive to declining food availability than are sheep. Vegetation growth in the model responded to random, annual variation in precipitation as well as to duration of the growing season, which also varied stochastically. Stocking rates of mountain sheep and goats on alpine ranges directly influenced nutrition of individuals by controlling the amount of forage available per capita.

In addition to nutritional effects on recruitment, simulated mountain sheep populations were regulated by infectious and parasitic diseases. We assumed that infectious disease caused by *Pasteurella* spp. can occasionally cause precipitous die-offs resulting from pneumonia epidemics, and that lamb survival is drastically reduced for several years following pneumonia outbreaks (Demarchi 1972, Bailey 1986). We further assumed the proportion of the population susceptible to pasteurellosis increases with increasing population density through recruitment of immunologically naive individuals and/or compromise of immunity in protected individuals (Anderson and May 1979, May and Anderson 1979, Anderson 1982, Dietz 1982, May 1983, Mollison 1987). Thus, probability of a die-off in the model increased linearly with density above a density threshold. We derived parameters for epidemic mortality rates from those documented during pneumonia epizootics in Rocky Mountain sheep herds throughout North America (Demarchi 1972, Feuerstein et al. 1980, Wishart et al. 1980, Onderka and Wishart 1984, Andryk and Irby 1986, Bailey 1986, Schwantje 1986, Festa-Bianchet 1988).

We also assumed that parasitic lungworm (*Protostrongylus* spp.) infections can cause high lamb mortality in mountain sheep populations (Woodard et al. 1974, Schmidt et al. 1979). Lamb mortality associated with lungworm infections increased as ewe density increased (Hudson and Stelfox 1976, Festa-Bianchet and Samson 1984, Festa-Bianchet 1987, Robb 1987, Samson et al. 1987) and ewe condition declined (Stelfox 1974, Festa-Bianchet and Samson 1984, Festa-Bianchet 1987, Robb 1987, Samson et al. 1987).

Mountain goat populations are far less subject to disease than are mountain sheep, but their numbers tend to be regulated by dispersal of juveniles (Geist 1982, Stevens 1983, Houston and Stevens 1988, J. A. Bailey unpublished data). We assumed that dispersal by juvenile mountain goats (age classes 1–5) reduced their survivorship at each time step. (We do not imply that all dispersing goats die, but the model accounts for dispersal and mortality in the same way.) Dispersal rates were 33 percent lower for females than for males (Stevens 1983) and were a constant fraction of cohort numbers.

Harvest was used to regulate populations of both species in the model. Achieved harvests were influenced by population objectives. The difference between population objectives and estimates of current population size determined the harvest objective. The number of animals harvested was a function of harvest objective and hunter success rate, which varied stochastically. Accuracy and precision of population estimates were controlled by the level of resources invested in census. Higher investment resulted in greater accuracy and precision.

Our model was written in FORTRAN 77 (Microsoft version 4.01) for execution on IBM compatible microcomputers. We used the TIME-ZERO Integrated Modeling Environment (Quaternary Software, Fort Collins, Colo.) to facilitate model construction and analyses.

Model Analyses

We used the model to examine mechanisms of regulation in populations of mountain goats and mountain sheep and to answer three questions:

1. What is the impact of introduced mountain goat populations on established populations of mountain sheep, and what ecological mechanisms are most important in controlling those impacts?
2. Do characteristics of alpine habitats (e.g., topography, primary production) influence the outcome of competitive interactions?
3. Can harvest increase the likelihood of coexistence between mountain goats and mountain sheep?

To address question 1, we examined simulated dynamics of each species in the absence of the other, and in absence of any management interventions. In these initial simulations, we presumed all regulating factors except harvest (i.e., food, disease, dispersal, parasitism) were operative.

We then structured a series of 100-year simulations that included both mountain sheep and mountain goats. Mountain sheep were introduced at year 0 and mountain goats at year 50. To facilitate comparison between the two halves of the simulation (0–50 years versus 51–100 years), we reinitialized all stochastic processes[1] at the beginning of year 51. Thus, any difference in behavior of mountain sheep populations in the first and second half of simulation runs could be attributed to effects of mountain goats. We first assumed that food supply alone regulated growth of both species. We subsequently added effects of parasitism and disease as regulators of mountain sheep populations and examined differences in model outcomes.

To address question 2, we examined effects of habitat variables on the outcome of competition. In separate model runs, we altered the percentage of habitat contained in cliffs and meadows and altered levels of annual net primary production.

To address question 3, we examined the influence of harvest on population trajectories with all natural regulators (food, competition, disease, parasitism) activated. We also examined two harvest regimes, "conservative" and "aggressive." The conservative approach included a minimal investment in census activity, a males-only harvest for mountain sheep (larger than 1/2 curl), and either-sex harvest of mountain goats. The aggressive strategy included heavy investment in census, specified harvests of both ram and ewe mountain sheep and either-sex harvest of mountain goats.

Results and Discussion

The model portrayed distinct patterns of growth in naturally-regulated populations of mountain sheep and mountain goats. In the absence of mountain goats, simulated mountain sheep populations displayed episodes of exponential increase followed sequentially by precipitous decline, temporary stasis and slow recovery (Figure 2A). These disease-induced sequences repeated at approximately 20-year intervals, with populations attaining peak densities of about 3 females/km^2. Similar patterns have been observed in populations of mountain sheep throughout the Rocky Mountains (Hudson and Stelfox 1976, Feuerstein et al. 1980, Hass 1989, Colorado Division of Wildlife unpublished data). In the absence of mountain sheep, simulated mountain goat populations displayed exponential growth followed by equilibrium (Figure 2B) typical of ungulates introduced into new habitat (Caughley 1970). Equilibrium density for mountain goats was about 4.6 females/km^2. During the first 10 years after introduction, simulated instantaneous rates of increase (r) for mountain goats ($r = 0.13$, Figure 2B) exceeded those for mountain sheep ($r = 0.11$, Figure 2A). These values resemble those calculated for growing populations of mountain goats (Hibbs et al. 1969, Vaughan 1975, Stevens and Driver 1978, Youds et al. 1980) and mountain sheep (Haas and Decker 1980, Jorgensen and Wishart 1986).

[1]The series of random numbers used for years 1–50 was identical to that used for years 51–100.

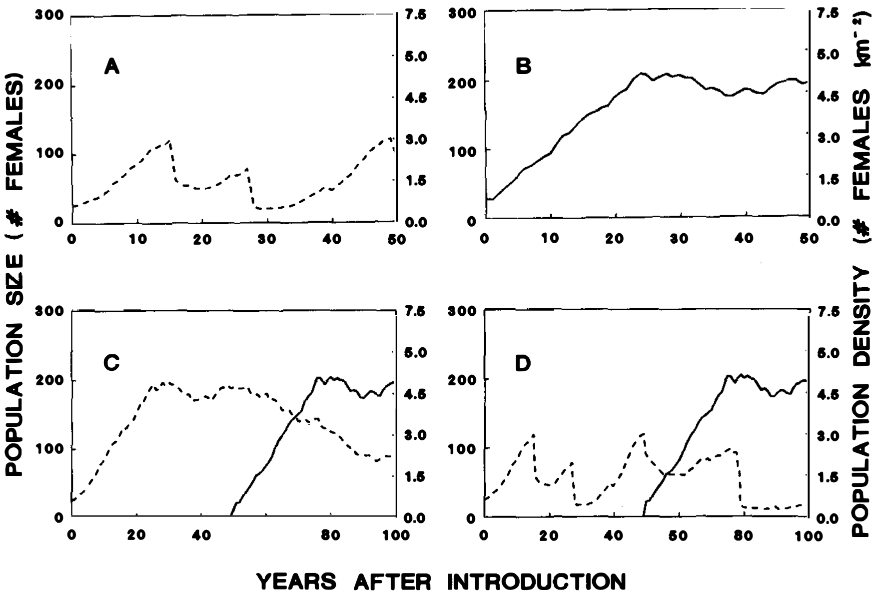

Figure 2. Simulated trajectories of ungulate populations introduced into alpine habitats in the absence of management. A—Population growth of mountain sheep regulated by intraspecific competition for food supply, epidemic disease and parasitism. B—Population growth of mountain goats regulated by intraspecific competition for food and dispersal. C—Effect of mountain goat introduction (solid line) on population performance of mountain sheep (dashed line), where mountain goats are regulated by food supply and dispersal and mountain sheep are regulated by food supply. D—Effect of mountain goat introduction (solid line) on population performance of mountain sheep (dashed line). Mountain sheep populations are limited by food supply, parasitism and epidemic disease. Mountain goat populations are regulated by food supply and dispersal.

When goats were included in simulations representing an established population of mountain sheep, the resulting performance of mountain sheep depended strongly on which mechanisms regulated their population growth. When we formulated the model so that food supply alone regulated population growth, the two species eventually reached a stable equilibrium (Figure 2C). That equilibrium point shifted downward in mountain sheep following introduction of mountain goats. Density-dependent effects on food supply acted to regulate population growth by reducing natality and increasing winter mortality in both populations.

When mountain sheep populations were regulated initially by the combined effects of food supply, parasitism and epidemic disease, and mountain goats were added to the simulation, the mountain sheep population appeared to be stable or increasing for 27 years following goat introduction (years 50–77, Figure 2D). Thus, introduction of goats initially appeared to *improve* the performance of sheep populations by increasing stability in their numbers. However, during year 77, this apparent stability was interrupted by a disease epidemic. The simulated mountain sheep population did not recover from that die-off (Figure 2D).

These patterns occurred because competition reduced natality in mountain sheep during years 50–77. This reduction in growth rate retarded the rate of increase in mountain sheep density and delayed onset of density-dependent epidemic disease. However, competition with mountain goats ultimately prevented the mountain sheep population from recovering vigorously following the die-off. Comparing these results (Figure 2D versus Figure 2C) emphasizes the importance of disease in influencing competitive interactions between these two species and the importance of time lagged effects.

Environmental conditions appeared to have little impact on the outcome of competition. When we increased net primary production by 1,000 kg/ha over the original values (1,700 kg/ha), equilibrium densities of mountain goats increased from 4.5 to almost 8 females/km^2, but population trajectories of mountain sheep responded only slightly (Figure 3A). This suggests that disease regulates mountain sheep numbers at levels well below the food-based carrying capacity of the environment.

In contrast, changing the proportion of habitat contributed by cliffs and meadows substantially influenced mountain sheep performance before introduction of goats and had moderate effects thereafter (Figure 3B). Mountain sheep populations responded to changes in habitat area to a greater extent than changes in production because of the effects of area on population density, and hence, on probability of disease outbreaks. Simulated mountain goat populations did not respond to these changes in initial conditions for habitat area. These patterns depend on our assumption that mountain goat populations can expand into meadows without penalty in their reproductive rates. To the extent that these assumptions are correct, then landscape characteristics of alpine translocation sites in Colorado will have little or no impact on the eventual outcome of competition but remain important considerations in selecting sites for potential mountain sheep translocations.

When we added hunting to the model, it was possible to achieve long-term equilibrium between sheep and goats using an aggressive harvest strategy propelled by liberal investment in census (Figure 3D). Conservative harvest regimes failed to eliminate disease cycles in mountain sheep populations and allowed mountain goats to prevail in competition with sheep, even when both sexes of goats were harvested moderately. Thus, we surmise that although mountain goats can be potent competitors with mountain sheep in the absence of management (Figure 2D), applying an appropriate harvest regime appears to allow coexistence of these species on alpine ranges at maximum sustainable densities (Figure 3C) because mountain sheep populations were stabilized by maintaining their densities below a threshold critical for disease outbreak.

Based on these simulations, we concluded that mountain goats can be potent competitors with mountain sheep and can significantly depress nonmigratory mountain sheep populations on alpine ranges. Characteristics of release sites may be relatively unimportant criteria in planning mountain goat translocations to those ranges. This is the case because of the demonstrated dispersal ability of mountain goats (Stevens 1983), and their apparent ability to thrive in meadow habitats used by mountain sheep. Preventing competitive interactions will depend to a greater extent on criteria for managing populations after introductions than on choosing sites before they occur. We surmise the fundamental criterion for mountain goat translocations within Colorado is a commitment to an aggressive harvest regime for both species and investment in inventory needed to direct that regime.

It is clear from our simulations that a "wait and see" approach to controlling mountain goat numbers involves substantial peril. Cyclic disease processes occur

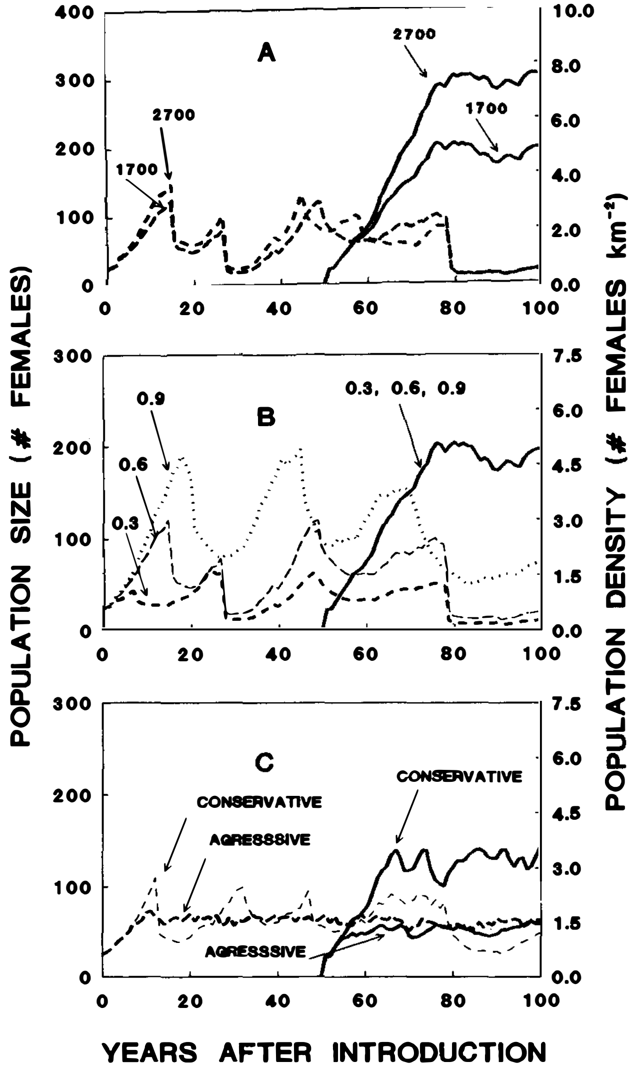

Figure 3. Effects of population and habitat management on simulated trajectories of ungulate populations introduced into alpine habitats. A—Effect of mountain goat introduction on population performance of mountain sheep, assuming two levels of net primary production in alpine habitats (1,700 and 2,700 kg/ha). Mountain sheep populations (dashed lines) are limited by food supply, epidemic disease and parasitism. Mountain goat populations (solid lines) are limited by food supply and dispersal. B—Effect of mountain goat introduction on population performance of mountain sheep, assuming different arrangements of cliffs and meadows in alpine habitats. Numbers by arrows give the proportion of the total area (cliffs + meadows) that is contributed by meadows. Mountain sheep populations (dashed lines) are limited by food supply, epidemic disease and parasitism. Mountain goat populations (solid lines) are limited by food supply and dispersal. C—Effect of mountain goat introduction (solid lines) on population performance of mountain sheep (dashed lines), assuming populations are harvested according to "aggressive" (thick lines) and "conservative" (thin lines) harvest regimes.

over time scales that make changes in mountain sheep population numbers difficult to compare among locations. Effects of mountain goats on demography of mountain sheep populations may be impossible to detect, particularly if sheep herds in areas receiving goat introductions are compared to ''control'' herds elsewhere. If those ''controls'' happen to be in a static or declining phase in the disease cycle, such comparisons are likely to be misleading. Moreover, the model suggests that inferring goats have no effect on sheep based on observing no change in mountain sheep may be dangerous, even if those observations occur over relatively long time periods (e.g., 27 years!). Such inferences offer spurious security about the future of mountain sheep if disease cycles remain poorly understood.

The outcomes of these scenarios rely heavily on our assumptions of mountain sheep and goat population performances and responses. These assumptions contribute uncertainty to any policy recommendations and motivate future research needed to reduce that uncertainty. Success in managing mountain sheep populations appears to hinge on preventing recurrent disease epidemics, regardless of whether sympatric mountain goat populations are present. We suggest that relationships between density of mountain sheep populations and their susceptibility to disease, as well as effects of harvest on animal distribution, offer important unresolved questions in mountain sheep management.

Both efficacy of population control for preventing disease outbreaks and strategies for regulating densities should be evaluated in controlled experiments incorporated into management plans for mountain sheep. These experiments should test effectiveness of both census and removal methods for achieving population objectives, and should monitor herd responses to management. To provide reliable conclusions, such management experiments will require careful design, combined with long-term commitment and cooperation of managers, biologists and researchers to apply and evaluate management treatments. We believe such endeavors are essential to enhance our comprehensive ability to manage for a diversity of ungulate species in alpine ecosystems.

Conclusions

Our example application illustrates several uses of simulation models in planning introductions. Models can be used to evaluate criteria for initiating translocations. Although such criteria usually focus on characteristics of the habit where translocations are planned, it is clear that introductions should be contingent on the wherewithal to execute specific management actions after species are introduced. For example, co-existence of mountain goats and mountain sheep on alpine ranges in Colorado will probably depend on the ability to harvest them effectively.

Models are also useful in revealing ''surprises'' in future performance of populations of interest. Our model illustrated that relatively long-term impacts of one species on another must be considered in criteria for introductions. The predicted local extinction of mountain sheep that occurred after 27 years of sympatry suggests that brief, empirical studies may offer a weak foundation for decisions on effects of introductions on competition between species. Models may be the only feasible way to make inferences over longer time scales.

Planning introductions should involve criteria for success, as well as a program designed to evaluate whether those criteria are met. Models can be fundamentally useful in identifying responses in the target population, particularly those of population performance. Our model demonstrated the substantial difficulty in making comparisons among populations when they cycle out of phase. This difficulty underscores the need for sophisticated experimental designs (Walters and Collie 1988, Walters et al. 1988) if those comparisons are to be reliable.

A common response to modeling efforts like the one we have outlined is that the best available information is simply not up to the task at hand. That is to say, we don't understand wildlife populations or their interactions with habitats well enough to model their behavior at any level of resolution. No doubt, there are times when we should heed such doubts. To the extent that it is better to be ignorant than misled, a modeling approach may not be appropriate when data are scarce and processes are poorly understood. However, it can also be argued that when our understanding is that poor, then the potential benefits offered by introducing a species cannot offset the risks involved. In such cases, prudence may demand that we leave well enough alone.

The utility of simulation modeling lies in forcing us to explicitly recognize the ". . . consequences of what we believe to be true" (Starfield and Bleloch 1986:3). This process can improve the quality of our choices and help us communicate why we made them.

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Summary Remarks

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The theme of this session "Introductions and Reintroductions of Wildlife Populations" is exceedingly important in modern wildlife management/science. Management of wildlife is becoming more intensive as habitats become fragmented and increased demands are placed on all natural resources. Some species (usually predators) have been completely eliminated because they compete with man, changes in land use eliminated essential habitats, or degredation of habitat quality. As man's awareness of the importance of balanced ecosystems increased, interest has developed in restoring species to formerly occupied habitats. This is in addition to the latent interest in many public interest groups and state wildlife agencies to fill "vacant" niches. Supported by the success of past introduction programs, such as for ring-necked pheasant (*Phasianus colchicus*), gray partridge (*Perdix perdix*) and chukar (*Alectoris chukar*) and, more recently for native species such as wild turkey (*Meleagris gallopavo*), ruffed grouse (*Bonasa umbellus*) and peregrine falcon (*Falco peregrinus*), there is strong interest in reintroduction and introduction of wildlife species.

Our speakers in this session have provided excellent thoughtful papers on a variety of issues important to success in reintroduction and introduction efforts. The presentations of Brocke et al. (1990) and Warren et al. (1990) demonstrate the importance of proper planning, while Gogan et al. (1990) describe a reintroduction effort currently in the planning phase. The success of these three efforts is not biologically assured, but the lynx (*Felis lynx*) and bobcat (*F. rufus*) efforts are clearly successful politically and have public support. Glass et al. (1990) provide evidence that strong public support exists for wildlife reintroduction programs and that people are willing financially to commit personal resources to these efforts. Wildlife does have determinable value! The papers of Batt and Nelson (1990) and Toepfer et al. (1990) present evidence that restoration programs using hand-reared birds have little chance of success. These authors present convincing arguments that quality habitat is the key to any successful reintroduction program. Paul Leberg (1990) provides insight into the importance of genetic considerations in introduction/reintroduction efforts. Realization of the importance of genetics in establishing and maintaining healthy wildlife populations is recent. This is a fertile area for research as we strive to understand better why some individual animals and populations do well while others perform poorly. Finally, Hobbs et al. (1990) demonstrate the usefulness of simulation modeling in understanding the dynamics of the effects of competition of introduced species on native species when both occur sympatrically. Too often wildlife managers fail to perceive the long-term impacts of introduction programs. However, the presentation of Hobbs et al. clearly indicates that substantial knowledge of species biology is required before modeling can be fully used.

Wildlife Translocations as Management Experiments

Man has been moving animals since at least biblical times (Noah's Ark). Unfortunately, most translocations have been poorly planned and even more poorly documented. In most cases there are no data available as to why and how a decision was made to reintroduce or introduce animals; data on numbers (age and sex) of animals released are inadequate or completely lacking, habitat data prerelease were not obtained and no postrelease evaluation was conducted. The philosophy was "dump and hope." Wildlife management/science has come a long way, but considerable room exists for additional growth. As the papers in this session clearly document, reintroduction and introduction efforts *require* considerable planning, prerelease habitat evaluations and postrelease evaluation *in addition* to firm biological knowledge about the species to be translocated. Further, all releases of wild animals must be treated as management experiments and be fully documented in obtainable reports. To do otherwise is a disservice to our supporting agencies and public interest groups. The time of "dump and hope" is forever behind us.

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Registered Attendance

ALABAMA
Molly A. Bartels, Ida Burns, William F. Burns, Jr., David C. Hayden, J. David Hoerath, Luther M. Owen, Jr., Celeste C. Spillers, Daniel M. Spillers, Doug P. Thompson

ALASKA
Janet Ady, Craig Altop, Bruce H. Baker, Michael Barton, Thomas H. Boyd, Jack Capp, Dave Cline, Bobbie Gossweiler, William A. Gossweiler, Junior D. Kerns, Calvin J. Lensink, Alan W. Maki, Sue Matthews, Douglas Miller, Wayne Regelin, Tom Rothe, Fred Samson, Roger B. Smith, Ken Spiers, Walter O. Stieglitz, Nancy Tanersley, Gerald R. Von Rueden, Glen Yankus, E. L. "Butch" Young

ARIZONA
Christine G. Bates, Bud Bristow, Mark Brosseau, Richard C. Etchberger, William F. Grossi, Eugene Knoder, Grace Knoder, Carol Krausman, Paul R. Krausman, Valerie Morrill, Jerome J. Pratt, Bill Shaw, Darcy Shaw, Duane L. Shroufe, Bruce D. Taubert, Mark C. Wallace, Frances Werner

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WITH CONSERVATION EASEMENTS

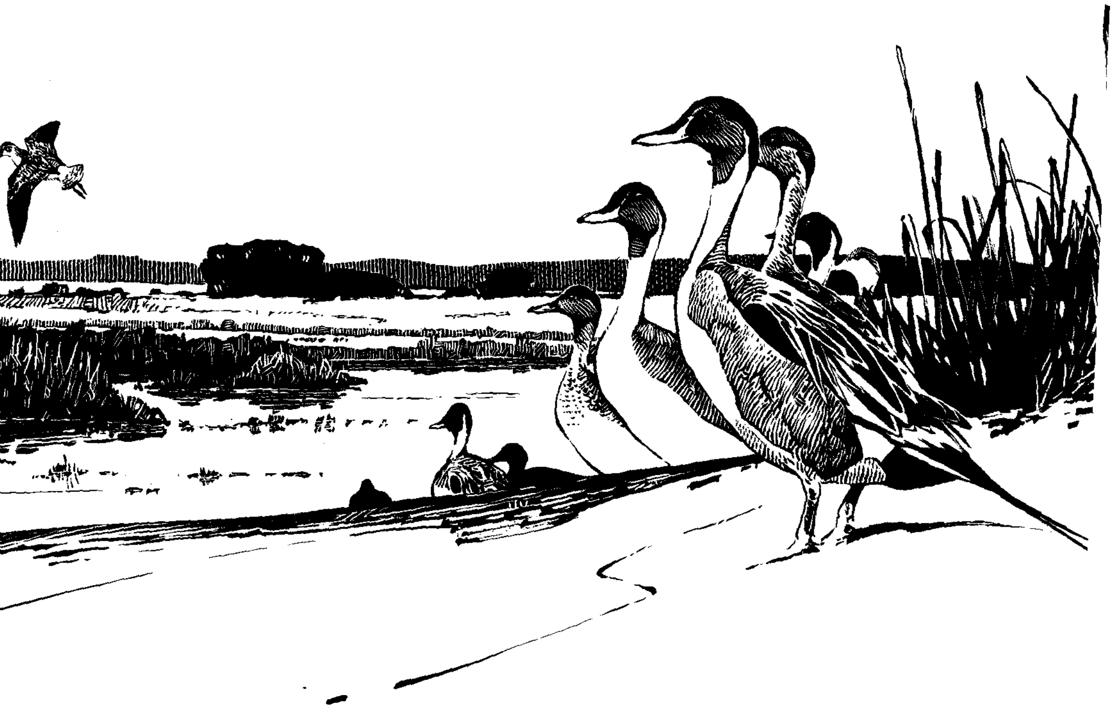
According to U. S. Senator Robert Kasten, Jr., of Wisconsin, speaking at the 55th North American Wildlife and Natural Resources Conference in Denver, Colorado, more than 95-percent of all wildlife lives on privately owned land. This land is threatened by state and federal estate systems that tax heirs heavily by the land's escalating value as developed land and by zoning laws that encourage suburban sprawl rather than accommodate natural areas, by supporting clustered development on reduced-sized lots surrounded by open space. All wildlife is at risk. Artwork and text courtesy of Stephen J. Small, editor, *Preserving Lands: Legal Issues,* P. O. Box 2242, Boston, MA 02107.

WITHOUT CONSERVATION EASEMENTS

"Some landowners are motivated by a love of the land accompanied by a growing awareness that government alone cannot assure conservation. 'It's up to the individual, too,' said Mr. Small. 'And the way to start is by seeking ways to control what happens to your own back yard.'

"The initial step for landowners who want to consider a conservation easement is self-education through reading. Leaving the exploration of such a notion entirely to traditional advisers such as family accountants and lawyers may not be the best way to begin because many professionals have limited experience."

New York Times
February 11, 1990



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