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Opening Statement

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Welcome to the 65th North American Wildlife and Natural Resources Conference. This is our fourth meeting in Chicago, and it has been three decades since the last meeting in 1970. The conference first convened in Chicago in April 1944. P. J. Hoffmaster, President of the International Association of Game, Fish and Conservation Commissioners reflected on progress made in wildlife restoration during the eight years since the first conference in 1936. This was an important time in the evolution of modern wildlife management, and the program included representatives from Canada, Mexico and the United States relating progress made in wildlife restoration programs.

Representatives from the United States focused on the renewability of natural resources and the potential for management to restore depleted species and habitats through programs funded by the Pittman Robertson Act, which was created shortly after the first North American in 1936. Mr. Hoffmaster's opening statement highlighted greater public awareness of the value of natural resources, more cooperation between various wildlife groups, and a feeling that the new programs were truly beginning to restore wildlife. Hoffmaster called on his audience not to be shortsighted as to the benefits to be had from fish and wildlife, citing not only "the hunter and his family" but "the much larger mass of citizenry" who need to be inspired and put to work on behalf of wildlife restoration. These comments fit nicely with today's concerns about the future of wildlife programs.

In 1954, W. Houser Davison, a representative from the National Association of Conservation Districts, addressed the issue "How Can We Live On An American Farm?" He told the audience that farming is a business, good farming begins but doesn't end with conservation, and that he supported locally led, voluntary conservation on the farm. These comments from almost 40 years ago are very similar to what we hear today.

In 1970, Ira Gaberison, President of the Wildlife Management Institute, spoke of the "present great wave of environmental concern," noting that scarcely a day went by without some official from the White House or another Executive Office releasing some statement of concern about environmental quality. On the plenary program was Russell Train, the first chairman of the new Council on Environmental Quality. Mr. Train described the new program as "nothing less than a new experience in government," "an experiment which will test whether we are wise enough to manage our affairs in a way which recognizes the essential interdependence of man and his environment." A session at this conference will assess the role of the National Environmental Policy Act.

Also at that 1970 Conference was a panel on the Public Land Law Review Commission and the Commission's impending report on the status of the legal framework for managing one-third of the nation's land. There is still great contention over how those lands are to be managed.

Let us note that great things have come out of the past three conferences in Chicago, and our hopes are equally high for this conference.

Nothing could be more important to this gathering of natural resource managers than the potential for truly historical legislation to fund the next wave of our nation's conservation, land protection, recreation and wildlife programs for decades to come. The Conservation and Reinvestment Act passed the House Resources Committee this past fall and is now moving toward action in the House of Representatives, with more than 300 sponsors. Not since enactment of the Pittman Robertson legislation, more than 60 years ago, has there been so much promise for improved funding for fish and wildlife restoration and conservation, as a foundation for this county's resources in the future.

Resources Committee Chairman Don Young of Alaska and ranking minority member George Miller of California have provided strong leadership in forging a bipartisan compromise. What is needed now is immediate, widespread support to Congress to achieve a goal of action on the House floor before the Easter recess. Realistically, to stimulate action in the Senate and to allow enough time to pass legislation, House action must occur soon.

There are significant issues yet to be overcome, such as continuing opposition from strident property rights proponents, opposition from those who don't approve of more government ownership of land, continuing concern from some environmental groups who believe the connection with offshore oil receipts will be an incentive for drilling, and very strong feelings by appropriators in the Congress who generally don't support dedicated funding. There are always important issues to be worked out in legislation with such potential sweeping impact. We must balance those concerns against the prospect of guaranteed funding, finally, for the Land and Water Conservation Fund and new funding for state wildlife and fish programs to meet real needs. Make no mistake about it, this is an issue whose time has come, and it needs to move forward now.

While it is clear what needs to happen in the House and at what pace, the Senate is more complex and less predictable. On February 29, in an effort to build support for similar legislation in the Senate Energy and Natural Resources Committee, Chairman Frank Murkowski and several other Senators introduced S. 2123, the Conservation and Reinvestment Act of 2000. The new bill is identical to H.R. 701, the House Resources Committee consensus bill, and other Senators have immediately joined on as cosponsors. On March 6, Senator Jeff Bingaman, ranking minority member on the Energy and Natural Resources Committee, introduced alternative bill S. 2181, the Conservation and Stewardship Act. Essentially the two new bills in the Senate pose the same issues and needs for compromise that preceded them in the House. S. 2181 earmarks more of the funding for an array of specific conservation programs. The stage is set for the Senate to move ahead with the same bipartisan diplomacy displayed in the House. The overwhelming support building in the House provides a good measure of what the bipartisan Congress can and should do.

The Administration continues to support more short-term appropriations measures to fund the Land and Water Conservation Fund and other programs. The Administration and a few environmental groups continue to be more focused on securing land, with less attention to providing programs for necessary management of those lands and resources in the future. Nevertheless, those appropriations requests broaden the public statement of the importance of these measures for wildlife, recreation and the American landscape in the future. The needs are clear, and polling data suggest that the American public is ready. What is needed is prompt House action by Easter and for the Senate to roll up its sleeves and go to work to make the kind of compromises that we expect of them. This is an opportunity for the 106th Congress to defy the image of a do nothing Congress and pass the most important legislation for wildlife and habitats in this century.

Let's stop to reflect on our own individual responsibility for this opportunity. Everyone in this room has a stake in the outcome! This is the result of decades of work and you each need to tell the Congress to act this year.

A serious problem continues to threaten the existing Federal Aid program that funds state fish and wildlife agencies. A GAO investigation of use of administrative funds has revealed poor record keeping, inappropriate use of funds for travel and moving costs, and lack of sound processes to use unobligated administrative funds for projects that should directly benefit wildlife conservation and the states. Federal Aid funds were used to cover overhead costs above their fair share. Keep in mind this issue refers only to a portion of the 6 to 8 percent of excise tax revenue provided by law for administrative cost to the Fish and Wildlife Service. GAO did not examine Service administration of more than 92 percent of the funds that continue to flow to the states for fish and wildlife programs.

The root of the problem is that there have been inadequate guidelines for how the administrative funds should be spent. The use of Federal Aid administrative funding has been the subject of several Congressional hearings and much adverse publicity in recent months. Continued reporting of accusations, many unfounded, have confused the public about the status of the operational programs. Also, continued reporting of details more than a year old ignores actions taken to fix the problems.

Hunters and anglers and the public at large have every reason to expect these administrative blunders to be fixed. Despite its administrative failings, the Fish and Wildlife Service remains an important partner in administration and essential oversight of federal aid programs. A regular FWS audit process of state programs is underway, and long overdue. Its findings demonstrate the need for this partnership and continued oversight. Similar regular auditing of Service administration must also occur. Businesslike approaches to Federal Aid issues are what are needed, not rumors and accusations. Legislation is proposed by the House Resources Committee as H.R. 3671, the Wildlife and Sport Fish Restoration Programs Improvement Act of 2000. In general, the legislation addresses the main issues of the clarity and purpose of administrative funds, and provides guidelines for a conservation grants program. The bill needs fine tuning to focus on these problems. As written it deals with internal agency details beyond what are appropriate, and does not provide enough funding to cover administrative costs.

Throughout the development of this problem and its advancement to the stage of a public scandal, not all partners in the program have had equal involvement. A formal oversight committee of state and federal agencies, industry and other stakeholders could provide consistent review to avoid these kinds of problems. Audits and reviews should be used to improve these vitally important programs—not to be made into political spectacles. The sooner this can be put behind us with an operational fix the better, and fish and wildlife will thank us the most of all.

For national wildlife refuges, the record of the last five years shows the greatest progress in several decades. The 1997 Refuge Improvement Act clarified the mission of refuges as taking care of wildlife first, and identified certain wildlife-dependent recreation uses as refuge purposes. The act passed the Congress with only one dissenting vote. Policies implementing it are currently being reviewed by stakeholders, public processes are handling individual refuge plans, and long standing issues of compatibility of nonwildlife-related uses are being solved.

This unprecedented, bipartisan support is the product of extensive work on behalf of national wildlife refuges by a wide array of stakeholders across the spectrum of wildlife and fisheries interests. The work of the Cooperative Alliance For Refuge Enhancement (CARE), composed of 18 different organizations, has elevated the profile of refuges in Interior, the Administration and Congress. More than 140 million new dollars for operations and maintenance of refuges have been provided through hard work by committed individuals and organizations. Responsible leaders in Congress, both Republican and Democrat, have personally supported more funding for refuges. Chairman Ralph Regula of the House Appropriations Subcommittee which deals with refuges, publicly stated his personal goal of solving the backlog of maintenance and operations by the centennial anniversary of refuges in 2003.

In response to the needs of refuges, Service Director Clark held an unprecedented meeting of refuge staff and stakeholders, and charted a strong course in "Fulfilling The Promise," a refuge vision for the future. Unfortunately, there continues to be largely internal disenchantment with the Service's administrative structure relative to refuges. An internal committee is reviewing how well that structure is or is not working, and Director Clark has pledged to take action as needed. Agency reorganization proposals are pending, and may be modified by results of these reviews.

The National Audubon Society has proposed separation of the National Wildlife Refuges as an agency outside the Fish and Wildlife Service (FWS), and has lobbied Congress to block Service reorganization. There is widespread concern and little support for this separate agency concept. Many feel this separation would have profound negative impacts on the FWS and refuges themselves. Separating refuges from the agency with primary endangered species and migratory bird authority, when management of so many refuges are targeted at those wildlife, doesn't make sense. Staffing and funding a new agency would remove a huge segment of funding from the Service. No matter how large operational and maintenance backlogs look for refuges or how impatient refuge supporters are for more progress, funding backlogs are larger for other land management agencies. A new agency would still compete for scarce dollars against other land management agencies with no assurance of a better outcome.

Unfortunately, this proposal was developed without engaging other conservation organizations about their concerns. It risks derailing the long-term commitment of those who have helped make significant progress. This is a divisive issue that needs to be put to rest. Those who think wildlife refuges need more attention are welcome to engage directly in the long-term hard work to obtain the resources needed for refuges.

A progress report on the development of the North American Bird Conservation Initiative (NABCI) provides exciting insights into what may become the broadest coalition for conservation ever assembled. For the first time, most of the leaders in management of natural resources and conservation are agreeing to work together toward a shared vision of bird conservation. Based on the success of the North American Waterfowl Management Plan and its companion legislation the North American Wetlands Conservation Act, that vision is benefitting from comprehensive plans for waterfowl, shorebirds, colonial waterbirds, and from a decade of work on songbirds through the Partners in Flight Network. Federal, state and provincial agencies and nongovernmental organizations in Canada, the United States and Mexico are organized and have started work on the ground.

The vision statement for NABCI calls for development of the necessary science foundation for comprehensive bird conservation, including monitoring and research. Delivery of bird conservation action focuses primarily on developing habitat-based work on the ground, in a joint venture approach similar to the one that has been so successful for waterfowl. Since we last reported on it, a National Committee has been formed in the United States, cochaired by the Director of the Fish and Wildlife Service and the President of the International Association. A federal committee has formed for the time, to link bird conservation efforts through all of the federal agencies whose actions affect the landscape.

Mexico and Canada are developing collaborative structures that match their country's processes. What is so exciting about this prospect is that it offers an opportunity to establish comprehensive coverage of all habitats in North America. A wide array of stakeholders can have a positive affect on the future of our diverse bird resources, by working on their habitats. Beyond birds, this offers the opportunity to harness the energy of other habitat-based groups regardless of what species they work for. The needs of elk, mule deer, wild turkey, bobwhite quail, grouse and the raptors that live on them, and even bats and butterflies and fish can be provided for. This is an emerging program of tremendous potential that may well chart the course for fish and wildlife habitat in its broadest sense for decades to come. It should be attractive to all wildlife and fish organizations and all organizations with a commitment to habitat.

The difficult issue of managing roads on the 192 million acres of the National Forest System has been thrust into a public dialogue that isn't dealing with the facts, has evoked emotional responses, and unfortunately has started with battlelines drawn. The outcome of this dialogue is one of the most important issues for the long-term welfare of wildlife management and public use on national forests, and it deserves our careful attention.

Roads through the national forests range from highways, secondary and tertiary roads, to managed gravel or more primitive roads. Most forest roads were developed to extract timber, minerals or gain access. Most of this was done without an overall plan or analysis, and many of the roads wouldn't be placed where they are in any reasonable current, planned approach. The Forest Service has proposed to address all of this in rule-makings and administrative guidance that deals with overall management of the road system, including off-road vehicles.

Those interested in the management of forest roads need to look clearly at the management needs of the road system and its huge maintenance backlog, public access, and the need to manage it and make tradeoffs for different resource values. Equally important are the strictly biological implications of road systems for management of wildlife and fish, and the issues of quality of the experience, whether hunting, fishing, hiking or just getting away from civilization. This latter value has been one of the most tremendous assets of the national forests. These are just a few of the fundamental issues that we should clearly evaluate before we take positions on what should happen with forest road systems.

There are legitimate needs for active management of forests that seem to be lost in this controversy. Forest health, fire management, wildlife management, and public access need to be returned to the overall dialogue. The turmoil over expectations and fears about what may happen through government action has led to a situation where any forest management issue seems to lead to questions about whether one is for or against imaginary proposals to lockup lands with no management or access. Yet we have not seen a specific proposal to affect things on the ground. It's time to calm down, look hard at what has been proposed and do the best we can for the future of the forest resource.

The dialogue on forest road policy, including roadless areas, has quickly become an emotional, politicized harangue that further obfuscates attention to some difficult choices for the future of our national forests. Hopefully, full information from Chief Dombeck on this program will shed light on where these policies are going and where they are not.

This conference has provided a forum for much of the past work that has led to the successful inclusion of fish and wildlife as coequal purposes under the 1996 Farm Act. Many of us are still involved in the implementation of the programs that offer such opportunity both for farmers and for fish and wildlife. After a couple of decades of some successes we now know that we need to market these programs and their benefits to the Congress, to the public, and to farmers and natural resource managers.

During the past year working groups at both the national and local level have fostered improved working relationships between NRCS, state and federal governments, and conservation NGOs. Eight state fish and wildlife agencies have innovative partnership arrangements with NRCS to cost-share technical positions, to provide the direct assistance that landowners need to implement programs on the ground. With staff and dollars on the decline from the federal sector, this has leveraged local funds in the pursuit of common goals. Several additional states are working to enhance these relationships now, and those who are not are missing a bet to get more bang for the buck in their state.

Cooperation between the agencies and NGOs has included much more work on Congressional awareness of the benefits of these programs to their constituents. Experienced landowners who understand the value of these programs have come to speak to their Congressional representatives in Washington. Prior to this conference, a Congressional tour introduced Illinois legislators to the benefits of farm programs in this state with direct involvement by NRCS, the Illinois Department of Natural Resources, and Partner NGOs.

A workshop on Farm Bill Conservation Program Results will be held in early July in Washington, bringing together representatives from state and federal agencies, commodity groups, fish and wildlife groups, and Farm Bill practitioners to highlight results of these programs. This information will not only educate the participants, but should provide a sound basis for expressing the value of these programs as we go into negotiations for a new Farm Bill in about two years.

New concepts are arising to widen the value of farm programs. For example, grassland easement programs have been pioneered in both South and North Dakota, and offer promise for addressing the needs for farmers and ranchers nationwide. In South Dakota alone, more than 600,000 acres have been enrolled in recent years, and there is promise for much more. These are voluntary, positive programs that benefit the farmer and fish and wildlife alike. They were not included directly in the last Farm Bill, but there are needs that range from native grasses on the Great Plains to grassland systems along coastlines and river deltas across the country. More attention also should be directed to long-term conservation and management mechanisms for sensitive habitats. The high cost of short-term progress may prove hard to maintain. This is the kind of thinking that needs to be introduced into the next round of farm legislation to widen the benefits and their geographical impact.

Work sessions at this conference have taken significant steps toward finalizing a revised booklet *How Much Is Enough,* which outlines habitat needs on a regional basis to meet existing wildlife plans and priorities. This large collaborative project with state wildlife agencies paid big dividends in expressing the needs of wildlife during the past Farm Bill debate, and should serve us well for the next one. This time more input for songbirds and other species should broaden its usefulness. All of this should be considered opportunity to forge stronger links with the agricultural community and leverage our funding to create better and wider benefits for fish and wildlife in America.

The conservation community was encouraged during the past year to see an awakening within the Department of Interior to the vast resource base of the Bureau of Land Management (BLM). At this conference a year ago, Director Tom Fry heard concerns about wildlife issues, the impacts of oil and gas development, and offers from various groups to work to improve the resource programs of the BLM. During the past year, the agency improved its outreach with a variety of potential supporters and began developing new initiatives to address the large number of resource issues facing the agency. Foremost among these issues and highlighted at the last conference, is the potential, even likelihood, of listings of a variety of birds and mammals under the endangered species act. Contrary to some who seem to think that listings are a victory, Director Fry and his staff have realized that if all of these potential listings come to pass, management and the use by the public of these lands and resources will become much more complicated. Proactive action is certainly needed. There has been little attention by the conservation community to the budget of the Bureau for its resource programs. An array of organizations has met several times to be briefed about BLM operations, resource program needs and budget needs. Attendees have included environmental, fish and wildlife, and livestock interests. Dialogue has begun about the wisdom of working together where we can identify common interests and support the Bureau and its work. This is encouraging after a long period of neglect of the agency, and reflects an awareness of the need to work together for a better outcome. Stay tuned, we hope for greater things from the Bureau in the future.

Last year, I ended the opening talk with an expression of concern about the federal budget debate. At that time Congressional leadership was sending mixed messages, hiding behind artificial caps on spending that eventually were ignored. We still have the same fundamental problem every year in facing the federal budget. Function 300 that provides funding for natural resources and environment has been on a downward slide for two decades, and as a percent of the national budget, it is less than half of what was allocated in 1980. It is in worse shape because of artificial budget limitations. America needs to spend some of its new prosperity on natural resources as an investment in the future. For any of these dreams of improved resource programs we must break this deadlock and go to work much more seriously on this fundamental flaw in national economic priorities, and we should do that now. A positive opportunity remains for this Congress to provide the leadership to begin to reverse this trend, by moving H.R. 701 through the House by Easter, forging a similar compromise in the Senate, and handing a tremendous gift to future Americans.

Ecosystem Management: From Rhetoric to Reality

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Ecosystem management has been one of the leading buzzwords in natural resource management during the last 10 years. It is a concept that has been embraced by most federal agencies, many state agencies and a number of private companies and organizations. While considerable activity has been directed toward ecosystem management, especially by federal agencies, it has produced few changes in the way on-the-ground management is actually being conducted.

Ecosystem management has been a widely used term, but it often is defined in different ways (Christensen et al. 1996). To some, it has meant looking at landscapes instead of individual sites or communities. To others, it has meant considering multiple species rather than single species. Still to others, it has consisted of balancing aspects of ecology and economics in planning decisions. To most, it has been a term that has had some conceptual meaning but little basis in application of day to day natural resource management. Often heard is the statement, "We are using ecosystem management—whatever that is." Yet, natural resource managers have been increasingly expected to address ecosystem restoration and the conservation of biological diversity. These managers have recognized that to achieve these objectives, they need to consider the ecological interactions of larger, mixed ownership landscapes. They also realize that natural resource disciplines must be better integrated in order to the requirements for achieving these ecological objectives. Finally, natural resource managers have become increasingly aware that to effectively meet the ecological objectives, there also needs to be the integration of social and economic objectives. All of these are reasons why ecosystem management has been embraced as a concept. Ecosystem management should provide the solutions to these resource management challenges. Yet, solutions to these resource problems are rarely observed as the direct outputs of existing ecosystem management programs. Many existing programs have failed to provide sufficient framework and knowledge of the practical application of ecosystem management, resulting in frustrated land managers, property owners and publics. Ecosystem management needs to move beyond the conceptual stage and become a practical way of doing managing resources. It is time for ecosystem management to move from rhetoric to reality.

What is Ecosystem Management?

Ecosystem management is a term that has been commonly used and abused. The Ecological Society of America (Christensen et al. 1996) identified a number of definitions that have been applied to ecosystem management. Grumbine (1994) provided a summary of the use of the term. Others decided that ecosystem management wasn't the right term after all. Rather ecosystem-based management or ecosystem approach was more appropriate. For ecosystem management to move from concept to application, it needs a specific definition of what it is and how it differs from other terms. Lackey (1999:33) noted: "Ecosystem management remained relatively free of controversy as long as it was defined in sufficiently general terms so that nearly anyone's policy position plausibly could be accommodated. Efforts to demand precision of thought, however, have forced deep-seated moral, philosophical and economic divisions to the surface."

A practical definition of ecosystem management is the integration of ecological, social and economic objectives for natural resource planning and management. The key to this definition lies in further defining the objectives that are being integrated. The ecological objectives of ecosystem management should address the maintenance and enhancement of biological diversity and ecosystem integrity within planning landscapes. Biological diversity is the variety of life and life processes and includes the levels of landscape, community, species and genetics (Keystone Center 1991). Ecosystem integrity is a related term operating at the community and landscape levels and specifically addresses the ecological processes that are essential for ecosystems to function in a defined and predictable fashion. The economic objectives usually focus on maintaining or enhancing the natural resource-based economies of a planning landscape, consistent with integration of ecological and social objectives. Social objectives include a wide suite of demands including cultural, aesthetic, recreational, spiritual and tribal. The focus on obtaining the ecological objectives while integrating the economic and social objectives distinguishes ecosystem management from many other activities. Ecosystem management strives to meet all three of these objectives (Kaufmann et al. 1994). It also attempts to attain the maximum amount of all three objectives simultaneously, not just a passing or token attention to any of the three.

There are other terms used by natural resource agencies that have confused the definition and use of the term ecosystem management. Specifically, the terms ecosystem approach and ecosystem-based management are frequently used synonymously with ecosystem management but differ considerably in application. These terms are often used to describe any new management activities that address more than one species, consider any type of ecological process or address both an economic or social concern in respect to an ecological objective. There is nothing wrong with these terms or these types of activities and they may make significant contributions to natural resource management. However, they are not ecosystem management. Ecosystem management involves fully addressing the conservation of biological diversity and ecosystem integrity and integrating then with economic and social objectives to the maximum extent practicable.

Strategies for Meeting Ecological Objectives

The greatest challenge for effective implementation of ecosystem management is how to address the complex objectives of conserving biological diversity and ecosystem integrity while allowing the integration of economic and social objectives. The science of conservation biology is in its infancy and has lacked an organized philosophical comparison of possible strategies. This has led to considerable confusion over how to address the ecological objectives of ecosystem management. Christensen et al. (1996) stated: "At one end of the spectrum in the current debate are wilderness purists who appear to believe that all management is bad, and that the best we can do for natural ecosystems is to leave them alone. This view ignores the fact that most ecosystems have already been substantially altered by human actions and are isolated and removed from their normal ecological context. At the other extreme are those who believe that human actions generally improve nature, and that no areas should be closed to intensive human activities such as commodity extraction and motorized recreation. A scientifically defensible and comprehensive view of ecosystem management has yet to be articulated, but is certainly somewhere between these two poles." A comparison and discussion of possible strategies that stem from different philosophical bases of ecosystem managers is an important first step for providing an operational framework.

Haufler (1999a, 1999b) described and contrasted various strategies for the conservation of biological diversity. A similar categorization of strategies is presented in Table 1. While these strategies are not mutually exclusive and various combinations are possible, this categorization does help frame differing views and their underlying philosophical basis for meeting the ecological objectives of ecosystem management.

Bioreserve Strategies

Bioreserve strategies are based on the philosophy that humans are the cause of the loss or decline in biological diversity and ecosystem integrity and, therefore, to conserve this diversity and integrity, areas must be established that

Table 1. Examples of approaches to conservation of biological diveristy (after Haufler 1999a).

Approach	Philosophy	Method of application
Bioreserve e.g., Noss (1994), Scott et al. (1993)	Human effects have led to loss of biodiversity. Conservation of biodiversity is best achieved by minimizing human activities across a system of core reserve areas with surrounding buffers and corridor connections.	Delineate a series of core bioreserve areas across the landscape that are restricted from human activity and connect these with a similar set of corridors.
Coarse fiter – habitat diversity e.g., Oliver (1992), Thomas (1979)	If a diversity of habitat conditions can be maintained across a planning landscape, then biodiversity will be maintained.	Identify different successional conditions, or other indicators of temprol dynamics, and assure that all successional condtions are provided across the landscape.
Coarse filter – historical range of variability e.g., DeLong (2000), Quesnel and Pinnell (2000)	Biological diversity evolved with and adapted to the conditions produced as a result of the complex of historical disturbances. Maintaining a landscape within this historical range of variability for disturbances will maintain biodiversity.	Determine historical disturbance regimes and manage landscape to stay within the historical range of variability of those disturbances.
Coarse filter – historical range of variability-based e.g., Haufler et al. (1996), Andison (2000)	Biological diversity depends upon the mix of conditions produced as a result of the complex of historical disturbance regimes but can be maintained with a representation of those conditions.	Determine complex of conditions produced by historical disturbance regimes, and manage to maintain representation of this full complex of conditions.
Fine filter e.g., Wall (1999), Thomas (1979)	Species are the basic units of biodiversity, so if all species can be maintained, biodiversity will be maintained.	Develop approaches that will account for the viability of all species. May use guilds, life forms, umbrella species, indicatior species or other such approaches.

exclude human influences. Various approaches have been proposed for use of this strategy, including the Wildlands Project (Noss 1994) and Gap analysis (Scott et al. 1993). The Wildlands Project advocates establishing a system of core reserves where human activity is minimized. These core reserves are surrounded by buffers to increase their effectiveness and linked by corridors of similar condition. Gap analysis attempts to ensure that all ecological community types are sufficiently represented within protected areas, such as wilderness or national parks, to protect hotspots of biodiversity.

Both of these approaches place human-related objectives of economics and social demands as polar to ecological objectives. This view emphasizes the separation of the three objectives rather than the integration of the objectives. Polarizing the three objectives of ecosystem management tends to alienate private landowners who are faced with the dilemma of deciding on conservation versus economic or social uses of their land. Consequently, the philosophical basis for the bioreserve strategy becomes a major impediment to its use as the strategy for addressing the ecological objectives of ecosystem management.

A bioreserve strategy would require an additional mechanism to check its effectiveness in meeting ecological objectives. Placing areas in a protected status does not assure that biological diversity is properly conserved, nor that ecosystem integrity is being maintained or enhanced. This is especially true in areas that have been altered by changes to historical disturbance regimes, such as the effects of fire suppression (Agee 1993, Covington and Moore 1994).

Historical Range of Variability Strategy

The historical range of variability strategy (Swanson et al. 1994, Morgan et al. 1994) focuses on maintaining a planning landscape within the historical range of conditions produced under historical disturbance regimes. The philosophical basis for this strategy is that biological diversity and ecosystem integrity were influenced by and adapted to the conditions produced by historical disturbance regimes. If planning landscapes can be maintained within this range of conditions, then biological diversity and ecosystem integrity will be maintained. The goal of this strategy is to maintain landscapes in a mix of ecological communities with similar community processes and dynamics as occurred under historical disturbance regimes. Conceptually, this strategy has both a very strong logical appeal and a very defensible scientific basis. Ecosystems and biological diversity were not static under historical disturbance regimes due to combinations of climatic shifts, changes in species ranges and adaptation of species. However, such dynamics also could be viewed as part of the historical range of variability and, thus, would be accounted for under this approach. Examples of use of this strategy are discussed by DeLong (2000) and Quesnel and Pinnell (2000).

The obvious drawback of this strategy is that it ignores the economic and social objectives. The approach strives to maintain landscapes as close to historical ranges as possible, while minimizing economic and social objectives that would require consideration of conditions outside the historical range of variability. By constraining land management to be within the historical range of variability, this strategy severely limits the opportunities to address economic and social objectives. In reality, very few landscapes can remain totally within historical ranges, so the goal is not likely ever to be achieved. So the question becomes, how far outside these historical ranges, in terms of communities or measures, can landscapes be without significant loss of biological diversity or ecosystem integrity?

Coarse-filter Strategies: Habitat Diversity

The concept of a coarse-filter strategy (Hunter 1988, The Nature Conservancy 1982) is to provide the right mix of ecological communities across an appropriately sized landscape, thereby supporting most, if not all, other levels of biodiversity. One application of this concept is the habitat diversity approach. The philosophical basis for this approach is that biodiversity concerns are primarily due to a loss of appropriate habitat conditions. If appropriate successional stages are delineated, and each is minimally represented within a planning landscape, then sufficient diversity of habitat conditions will be supported to provide for all biological diversity. Oliver's (1992) landscape ecosystem management and Thomas's (1979) Blue Mountain management plan are examples of this approach.

Habitat diversity approaches shift the focus of conservation of biological diversity away from the protection status of bioreserve approaches to the successional stages of ecological communities present within a landscape. The problem of the polarization of biodiversity versus human activity is avoided; although, maintenance of some successional conditions would require minimal human impacts on representative ecological communities. The success of habitat diversity approaches hinges on the effective classification of ecological communities to be maintained. Habitat diversity approaches do not reference historically occurring conditions; therefore, they potentially require maintenance of community conditions that never occurred historically or overlook certain ecological communities that were maintained by historical disturbance regimes.

As with bioreserve approaches, habitat diversity approaches still require an additional mechanism to assure their achievement of ecological objectives. Thomas (1979) linked the habitat diversity approach with a fine-filter analysis based on vertebrate life forms.

Coarse-filter Strategies: Historical Range of Variability-based Approach

The historical range of variability-based approach uses the concept of historical range of variability to describe and understand biological diversity and ecosystem integrity as it occurred under historical conditions. Using the historical range of variability as a reference, it then identifies the appropriate level of representation of these conditions to maintain biological diversity. The philosophical basis for this approach is similar to the historical range of variability strategy. Put simply, biological diversity and ecosystem integrity have been a product of the historical disturbance regimes and the conditions they produced within a planning landscape. However, this approach adds the philosophical view that biological diversity and ecosystem integrity can be maintained by providing a representation of the historical conditions, rather than setting the historical range of variability as the goal. This provides for the integration of economic and social objectives by allowing the consideration of acceptable levels of risk to ecological objectives through adequate representation of historical conditions. An example of this approach is described by Haufler et al. (1996, 1999). When compared to the habitat diversity approach, a critical benefit of the historical range of variability-based approach is it provides an understanding of the disturbance processes and conditions present that supported biodiversity and maintained ecosystem integrity in the past. This provides the framework to identify the specific conditions that need to be restored or maintained to support biological diversity and provide for ecosystem integrity within a landscape. This approach also does not assume that human activities and ecological objectives are at odds, as in the bioreserve approach; although, many of the historical conditions represented would require minimal human impacts to qualify as representative conditions.

As with bioreserve approaches and habitat diversity approaches, the historical range of variability-based approach will require a mechanism to check the attainment of ecological objectives. However, basing the coarse filter on an understanding and representation of historical conditions reduces the likelihood that species might not be adequately provided for through the representation of communities within a landscape.

Fine-filter Strategy

Fine-filter strategies strive to maintain all native species within a planning landscape. The philosophical basis for this type of strategy is that species are the basic building blocks of biological diversity; so that, if the occurrence or viability of all species can be maintained, the ecological objectives will be met. Examples of this approach include Wall (1999) and Thomas (1979). This approach avoids the difficulty of developing and delineating an effective coarse filter on which each of the coarse-filter approaches depends, however species habitat models still would require an appropriate classification system. Further, fine-filter strategies allow considerable management discretion in determining how to provide the needed conditions for maintenance of species, as they focus on providing the specific habitat needs of species rather than on any mix of communities or processes for providing these needs.

Fine-filter strategies have some severe limitations for meeting ecological objectives of ecosystem management. The number and complexity of species that must be accounted for can be staggering. For example, the Columbia River Basin Assessment (Interior Columbia Basin Ecosystem Management Project 1997) estimated that 31,700 terrestrial species occurred within the management landscape. It is obviously not possible to individually consider the needs of such large numbers of species. Even if they could be considered individually, their conflicting needs would be difficult to reconcile. Alternative methods of aggregating species needs have been proposed including guilds (Morrison et al. 1992), life forms (Thomas 1979, Wall 1999) and indicator species (Morrison et al. 1992). These efforts have usually only targeted vertebrate species. In addition, the use of aggregations or single species to represent the needs of broader groups has been questioned (Hunter 1990, Morrison et al. 1992), as has the feasibility of this approach for meeting landscape level biological diversity objectives (Marcot et al. 1994, Risbrudt 1992). Further, the fact that this approach does not directly address ecological communities makes it unlikely that it will meet the equally important objective of ecosystem integrity.

Combination Strategies

The strategies for addressing conservation of biological diversity and ecosystem integrity discussed above clearly stem from differences in philosophies and, thus, result in different approaches or methods. However, the differences among approaches are not typically as great as inferred. In addition, combinations of approaches are not only possible but are frequently practiced. For example, coarse-filter approaches must designate areas on the landscape for specific representation of the coarse filter. Using a broader definition of bioreserves as areas that are delineated for the primary purpose of meeting specific biological diversity or ecosystem management objectives, areas designated in a coarse-filter strategy could then be considered bioreserves. Other combinations of approaches occur when a coarse-filter approach is checked with individual species assessments, a concept that overlaps with a fine-filter strategy. The point of these examples is that there are a number of possible strategies and permutations for addressing the ecological objectives of ecosystem management. However, it is important for ecosystem management initiatives to recognize the different philosophies and evaluate the appropriate strategy to be used.

Selection of a Strategy for Addressing the Ecological Objectives of Ecosystem Management

As discussed above, meeting ecological objectives has been a primary focus and challenge in the implementation of ecosystem management. Conservation of biological diversity and ecosystem integrity is a goal of many environmental groups independent of ecosystem management. This has been a reason for the range of strategies for the conservation of biological diversity as well as the confusion and controversy over appropriate methodologies. Ecosystem management has as a fundamental component the integration of ecological, economic, and social objectives, not just a focus on the ecological objectives. Therefore, strategies focusing simply on the conservation of biological diversity, to the exclusion of economic and social objectives, have a basic inconsistency with implementation of ecosystem management. The historical range of variability strategy is an example. This strategy leaves no room for integration of objectives; therefore, it is a very poor strategy for use in ecosystem management. Bioreserve strategies allow for integration by zoning levels of human activity, but the philosophical emphasis on minimizing human impacts has a polarizing effect on economic and social objectives. These factors need to be recognized and considered when selecting approaches for use in ecosystem management.

An Ecosystem Management Example

Boise Cascade Corporation began internal discussions on ecosystem management in 1993. At that time, the company made a decision that it wanted to be proactive in the development and implementation of ecosystem management, rather than simply commenting on the activities of others. Consequently, it initiated two collaborative ecosystem management projects in 1994, one each in Washington and Idaho, and a third in 1995 in Minnesota. The company committed to staffing each project with two to three full-time professionals for a five-year duration. These projects were designed to apply a similar process for ecosystem management across large, mixed ownership landscapes in collaboration with other landowners, agencies, conservation organizations, and academic institutions. A general description of the process was described by Haufler et al. (1996, 1999). An overview of the findings of the Idaho project is discussed here as an example of the application of an approach to ecosystem management. The project emphasized the ecological objectives of ecosystem management but also included an economic evaluation relative to forestry activities.

The project followed the 10 steps of the ecosystem management process described by Haufler et al. (1999); although, it only proceeded through the steps highlighted in Figure 1. The remaining steps would involve a large public participation process beyond the scope of the project. However, the project has helped generate the data and maps necessary to develop informed decisions and to finish the process.

The project used a historical range of variability-based approach. The first step was the delineation of a planning landscape of sufficient size to address the ecological objectives. In Idaho, the delineated landscape was the Idaho Southern Batholith (Haufler et al. 1996), an area of approximately 2.2 million hectares, of which Boise Cascade Corporation owns approximately 65,000 hectares. The next step was the development of appropriate coarse filters for the landscape, based on describing ecological communities occurring under historical disturbance regimes. A tool termed an ecosystem diversity matrix (Haufler 1994, Haufler et al. 1996) was used as a framework for developing the coarse filters based on appropriate classifications. Four interacting ecosystem diversity matrices were identified to describe the entire coarse filter: a forest matrix, a riparian/wetland matrix, an aquatic matrix, and a grass/shrubland matrix. The project produced and conducted field-testing on the forest and riparian/wetland matrices, conceptualized the aquatic matrix, and did not address the grass/shrubland matrix. The forest ecosystem diversity matrix (Mehl et al. 1998) classified the landscape according to an ecological classification system. An ecological classification delineates repeatable landscape units that exhibit predictable species assemblages and structures throughout their successional trajectory and when exposed to disturbance. Understanding the potential natural vegetation of a site and its preceding seral communities is critical to understanding the overall patterns and processes operating on a landscape. Therefore, to identify the full range of conditions possible for the Idaho Southern Batholith landscape the matrix also incorporated a classification of successional stages termed vegetation growth stages. Vegetation growth stages provide the ability to identify and map temporal changes as influenced by fire, the primary historical disturbance factor in this landscape. Fire influenced the 11 different categories of ecological sites, termed habitat type classes, through either understory, non-lethal fire regimes, stand replacing fire regimes, or a mix of the two (Mehl et al. 1998). The effects of these fire regimes, as well as additional disturbance factors including insects and disease, were investigated as to their historical influences and modeled for each of the 11 habitat type classes. By also modeling stochastic variation within the bounds of the disturbance regime, the historical range of variability (Morgan et al. 1994) of each vegetation growth stage within each habitat type class was determined (Table 2). The values presented in Table 2 are the percentages of area within a habitat type class, or column of the matrix, that were calculated to have occurred within the planning landscape

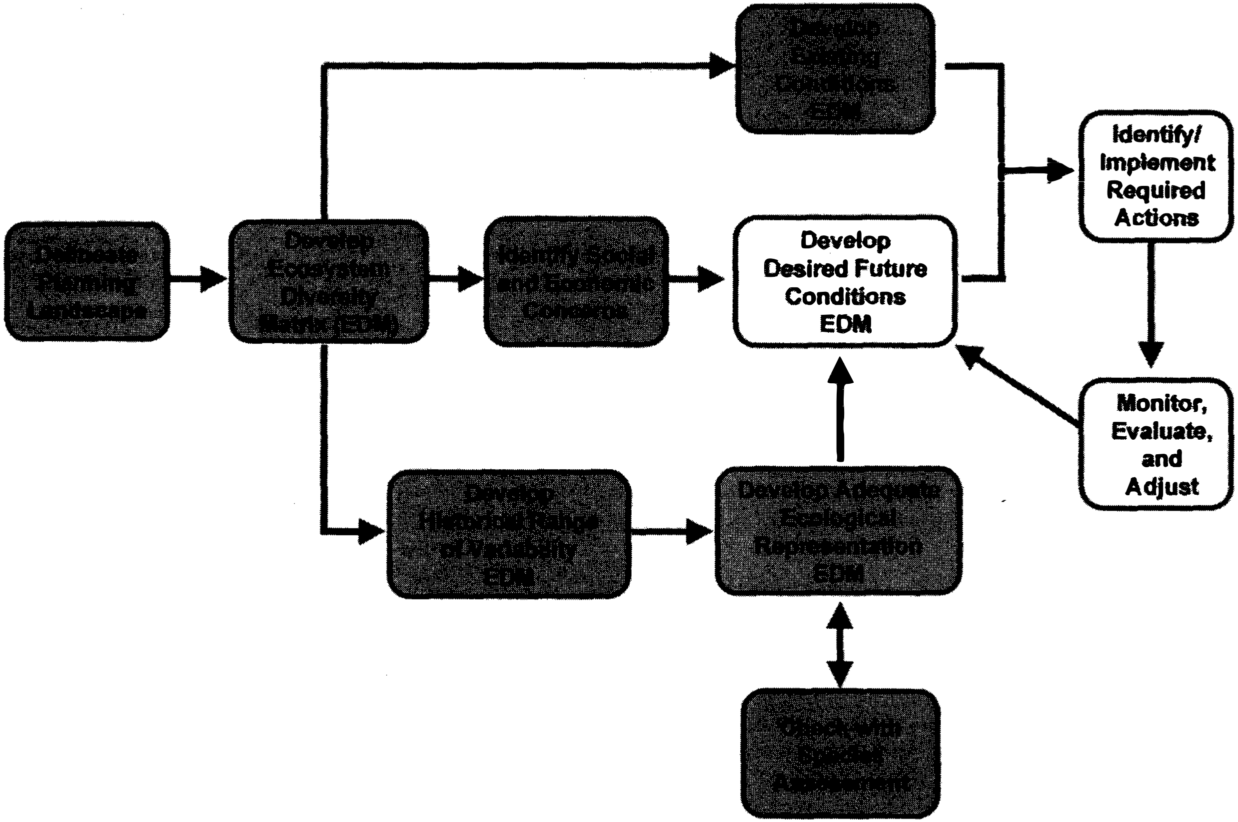


Figure 1. A process for ecosystem management, after Haufler et al. (1999) showing the steps in the process (shaded) that are described in this manuscript.

Table 2. A simplified forest ecosystem diversity matrix for the Idaho Southern Batholith Landscape listing the historical range of variability in percentage of area for each cell or ecological unit of the matrix that was determined to have occurred over an approximately 500 year time period. Total represents total amount of the habitat type class in the planning landscape.

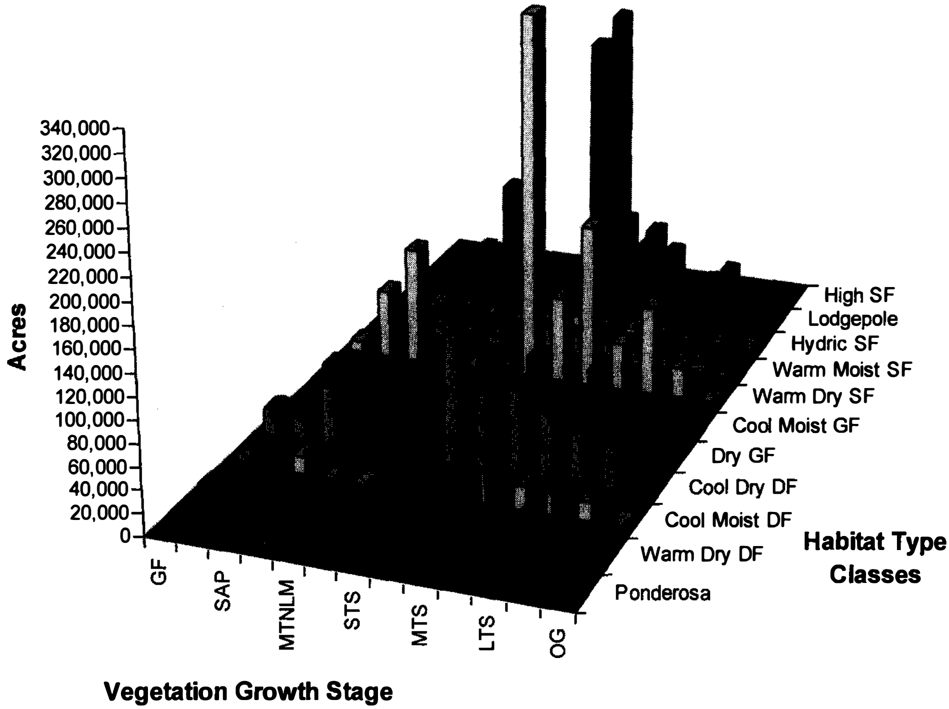
	Habitat type class (acres)			
Vegetation growth stage	Dry Douglas-fir	Dry grand fir	Cool, moist grand fir	Warm, dry subalpine fir
Shrub/sapling	0-4	0-6	5-16	0-11
Understory fire regime				
Small tree	0-4	0-11	0-12	0-4
Medium tree	3-22	1-16	2-26	2-8
Large tree	59-99	66-99	19-59	3-8
Stand replacing fire regime				
Small tree	0	0	1-9	8-26
Medium tree	0	0	2-19	12-26
Large tree	0	0	8-26	5-15
Old growth	0	0-1	1-5	2-6
Total	546,352	94,322	187,497	895,027

over an approximately 500-year time span prior to European settlement (Steele 1994) and the subsequent alteration of the landscape.

In addition to determining the range of historical conditions, the project also mapped the existing landscape conditions. This was accomplished by mapping site complexity and vegetation growth stages. Site complexity or habitat type classes were mapped based on a model (Warren et al., personal communication) that used abiotic factors to delineate site differences. Ground plots distributed across the landscape then were used to adjust model outputs. Vegetation growth stages were mapped using classified satellite imagery. An overlay of these two geographic information system (GIS) coverages allowed for the quantification of the amount of each cell, or ecological unit, within the matrix. A graphical display of the full matrix depicting the area of each ecological unit is presented in Figure 2. In addition, the area of average coverage for each ecological unit of the historical range of variability matrix was calculated and is presented in Figure 3. Comparison of these two matrices provides a visual tally of changes that have occurred in landscape composition over the last 100 years.

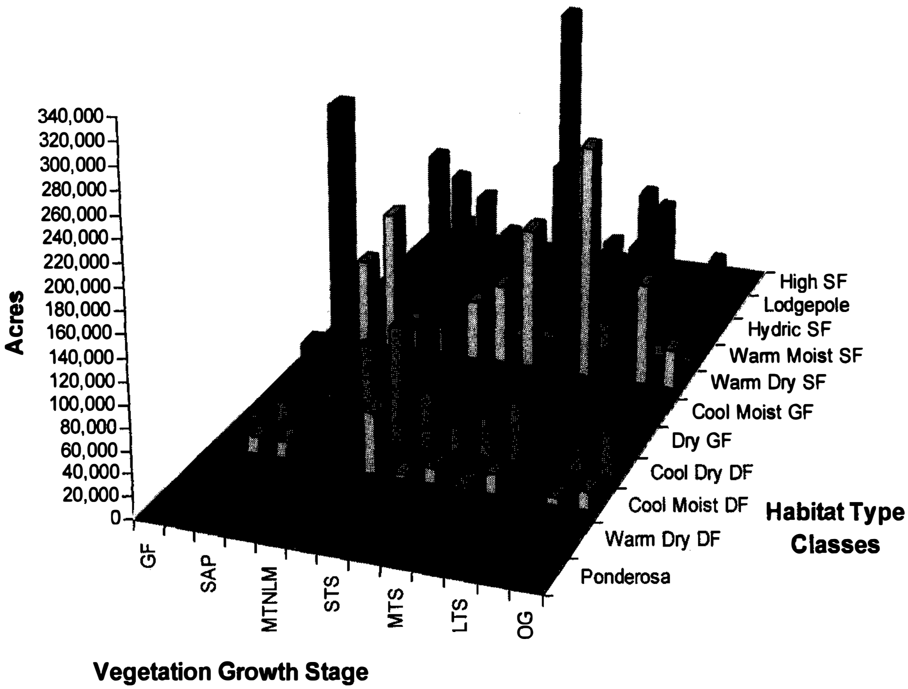
This ecosystem management process (Haufler et al. 1999) also involves calculating an estimate of threshold levels for the coarse filter. These threshold levels are needed to maintain ecological objectives above an acceptable level of risk to biodiversity elements, such as viability of any given species, or function-

Figure 2. A graphical display of the forest ecosystem diversity matrix for the Idaho Southern Batholith Landscape showing acreage of existing ecological units of the matrix



ing of identified ecological processes. While the determination of the acceptable level of risk is a societal decision, our process provides a methodology for determining thresholds with a measure of risk. These thresholds are referred to as adequate ecological representation. For a coarse filter to function as an effective strategy, adequate ecological representation must be determined relative to this coarse filter. To accomplish this, adequate ecological representation can be determined as a percentage of the historical range of variability for each cell or ecological unit of the matrix. At this time, we recommend using a set percentage of the maximum of historical range of variability for each ecological unit of the forest ecosystem diversity matrix as a means of determining adequate ecological representation. In fact, empirical examination of habitat loss as a causative factor for species viability concerns has served as the basis for adequate ecological representation. An initial level of 10 percent of the maximum historical range of variability was proposed by Haufler et al. (1999) as the basis for calculating threshold amounts. These amounts can then be further tested for probability of risk to ecological objectives. Using this approach, adequate ecological representation for each ecological unit of the Idaho Southern Batholith Landscape (Table 3) was identified.

Figure 3. A graphical display of the forest ecosystem diversity matrix for the Idaho Southern batholith Landscape showing the mean acreage of the calculated historical range of variability for each ecological unit of the matrix.



Whether or not this level of representation will be deemed an acceptable level of ecological risk by the majority of society involved in determination of desired future conditions would be decided in the decision-making phase of the process. However, these identified levels will provide an immediate indication of where the landscape is in greatest need for restoration efforts. For example, a comparison of the existing conditions matrix (Figure 2) with the simplified adequate ecological representation matrix (Table 3) reveals a lack of representation of about 21,000 hectares for the large tree, non-lethal fire maintained vegetation growth stage of the dry Douglas fir habitat type class.

Some might prefer that adequate ecological representation not be quantified, but rather remain a general goal of management. This is an unacceptable approach to ecosystem management for several reasons. First, if an historical range of variability-based approach has been accepted as the operative strategy, failure to determine needed threshold levels does not distinguish efforts from those of the historical range of variability approach. This leads to an inability to effectively implement ecosystem management as the maximum inte-

Table 3. A simplified forest ecosystem diversity matrix for the Idaho Southern Batholith Landscape listing area required to meet adequate ecological representation thresholds based on 10 percent of the maximum of historical range of variability for each ecological unit of the matrix. Total represents total amounts of the habitat type class in the planning landscape.

	Habitat type class (acres)			
Vegetation growth stage	Dry Douglas-fir	Dry grand fir	Cool, moist grand fir	Warm, dry subalpine fir
Shrub/sapling	2,185	566	3,000	9,845
Understory fire regime				
Small tree	2,185	1,038	2,250	3,586
Medium tree	12,020	1,509	4,875	7,160
Large tree	54,089	9,338	11,062	7,160
Stand replacing fire regime				
Small tree	0	0	1,687	23,271
Medium tree	0	0	3,562	23,271
Large tree	0	0	4,875	13,425
Old growth	0	94	937	5,370
Total	546,352	94,322	187,497	895,027

gration of ecological, economic and social objectives. Failure to quantify threshold levels means that needed restoration efforts will remain ambiguous and contentious, impeding effective restoration efforts. Further, collaboration is recognized as a critical factor to meet ecosystem management objectives in most, if not all landscapes. Ambiguous objectives and thresholds will frustrate opportunities for collaboration, as private landowners may fear that the effort is simply an open-ended attempt to control their land management activities. By applying a defined, scientific process to quantify specific thresholds of adequate ecological representation, all participants can trust and endorse these levels, while also better understanding their potential contribution to the overall collaborative effort.

Using the process for ecosystem management outlined above to develop a view on adequate representation of the coarse filter provides a basis for assuring ecological sustainability within the planning landscape. However, as a check on the determined levels of adequate ecological representation, we have also developed a methodology for a habitat-based approach to species viability (Roloff and Haufler 1997). This check was used to evaluate the likely persistence of selected species within the Idaho Southern Batholith Landscape under various management alternatives but with adequate ecological representation maintained as a constant.

Boise Cascade Corporation also conducted economic analyses of selected management alternatives that could influence the amounts of timber or fiber harvested from the planning landscape over a 100-year planning horizon (Boise Cascade Corporation, unpublished data). These analyses revealed that adequate ecological representation could be met while maintaining a positive net present value throughout the planning timeframe. The analyses also revealed that establishing an extensive bioreserve system that excluded management activities failed to maintain adequate ecological representation for a large number of historically occurring communities or ecological units. Management designed to meet adequate ecological representation but without regard to associated economic factors, produced an ecologically sustainable landscape but with a very high cost.

Boise Cascade Corporation's three ecosystem management projects demonstrated that the identified process could be used with today's technologies and data sources to delineate and describe a coarse-filter approach checked with a habitat-based species viability assessment to achieve ecosystem management objectives. However, the projects also revealed the need to utilize a fairly fine scale of resolution in delineating and mapping forest communities and to also use a fine scale of resolution in sampling and describing associated attribute data. While assessments of ecological conditions can be made at a variety of scales, those made at coarse scales can only reveal general trends and are not very effective in accomplishing ecosystem management objectives. The projects have also revealed the critical role of the coarse filter for use in ecosystem management. Classification systems that do not allow an understanding or incorporation of historical disturbance regimes for future temporal change simply cannot be used to provide historical context and reference, which is required by the historical range of variability-based approach.

Recommendations for Ecosystem Management

Ecosystem management can be effectively implemented using the knowledge, technology and data available today. However, there are a number of barriers that complicate its effective implementation. The most effective level for implementation of ecosystem management is at a local level, involving partnerships of county governments, township or municipal governing groups, local conservation organizations, industries, and landowners (Kernohan and Haufler 1999). These efforts need to include state and federal agency representation and involvement, but should be lead at the local level. This level of implementation will be most effective for several reasons. First, it is at this level that the needed emphasis on fine scale data and mapping can best occur. Second, collaborative efforts initiated and lead at the local level can engage and secure commitments from private landowners and industries that are usually impossible to achieve through state or federal initiatives. Distrust of private landowners and industries towards what might be perceived as government attempts to control their lands, makes initiatives lead by state and federal agencies unlikely to succeed. Boise Cascade Corporation's projects were effective in obtaining involvement and commitment from a diversity of government agencies and local groups. It was a privately lead effort that did not invoke the skepticism of private landowners often observed in similar initiatives lead by state or federal governments.

For local collaborative efforts to be effective, they will need both technical and financial support. Developing scientific data and knowledge about the planning landscape is essential to making informed management decisions. Local initiatives seldom have access to data of sufficient resolution and quality. They do not have the technical knowledge for ecosystem management and do not know how to interpret and use data to make ecosystem management decisions. Funding and technical assistance to local efforts can be provided from a number of sources. Federal and state agencies, foundations, and legislative allocations could be significant funding sources. Technical assistance may be available from agencies, institutes or organizations with professional staffs. A particularly important technical contribution can be GIS support to local initiatives. The size and complexity of planning landscapes that must be addressed to meet ecosystem management objectives require sophisticated mapping and data analysis tools to understand existing conditions, and to project future landscape conditions. This technical assistance should not attempt to influence local decisions as to desired conditions of the landscape. Instead, the objective should be to develop the scientific foundation and assist in the compilation and interpretation of information, while also providing information on the alternative outcomes of proposed management scenarios.

At the state level, natural resource agencies can play a more significant role in supporting ecosystem management initiatives than generally occurs today. State agencies can take a lead in delineating and mapping planning landscapes and in encouraging collaborative ecosystem management efforts within these planning landscapes. States agencies can provide GIS support as well as data gathering and analysis to collaborative ecosystem management efforts. They also can provide funding and general operational frameworks for initiatives.

State management programs will be significantly enhanced by involvement in ecosystem management initiatives. Effective ecosystem management will assist states in coordinating the activities of its various natural resource agencies. Many state fisheries, wildlife and forestry agencies operate and make planning decisions independently of each other. Ecosystem management can provide a common and coordinated approach for integration of landscape planning among these agencies. Further, because ecosystem management provides the basis for maintaining biological diversity, it can help states maintain authority for species management rather than having this authority usurped by the federal government when species are listed under the Endangered Species Act.

Federal agencies have generally been perceived as leaders in implementation of ecosystem management. However, they currently have several significant barriers to implementing effective ecosystem management. As mentioned in the discussion of local efforts, federally led efforts are looked upon skeptically by many private landowners due to concerns over government control of their lands. Consequently, federal agencies are usually careful to confine their ecosystem management efforts to federal lands only. However, as stated earlier, meeting the ecological objectives of ecosystem management requires the consideration of large, mixed ownership landscapes. Thus, federal efforts would be more effective if they were directed at assisting local collaborative efforts rather than striving to address ecosystem management objectives on federal lands alone. Unfortunately, federal lands face many constraints in being involved in collaborative planning efforts. The various legislative acts that direct federal land planning procedures do not allow federal lands to be readily incorporated in collaborative planning efforts. These acts need to be modified so that federal lands can be included in collaborative planning efforts in a timely and supportive manner. This does not mean that national or regional perspectives should be overridden by local decisions, but that a more efficient and effective process for involving federal lands in collaborative efforts needs to be enabled through legislative change.

Ecosystem management can also help federal agencies through better application of both ESA and NEPA requirements. Effective ecosystem management provides a landscape-level assessment of cumulative effects. These can be determined at a community level through the coarse-filter analysis or at the species level if the habitat-based species viability approach is applied. An EIS can be prepared for the overall landscape. Federal management actions that maintain the landscape above identified threshold levels will have addressed cumulative effects identified through the EIS process developed from the ecosystem management information. Specific projects would then only would require an EA confirming their compliance with the overall landscape EIS. Similarly, the landscape plan could be the focus of Section 7 consultation for the ESA. Projects that comply with the overall landscape plan and identified thresholds would not need individual jeopardy determinations, only an assessment that the project was in compliance with the landscape objectives. In this way, ecosystem management could improve effectiveness and efficiency of both NEPA and ESA regulatory processes.

State and federal administrators should strive to enhance the ability of collaborative efforts to reach sound management decisions rather than making arbitrary top-down decisions on land uses or allocations. Programs should be encouraged that recognize and support the right decisions being made at local levels, rather than trying to set uniform guidelines or allocations. While numerous examples of these types of supportive programs and policies exist, numerous examples of inappropriate top-down decisions also can be identified. These top-down decisions only serve to alienate various potential participants and reinforce the view that these decisions are going to be made in this top-down manner regardless of collaborative efforts.

Conclusions

Ecosystem management is the integration of ecological, social and economic objectives in natural resource management at landscape levels. To be considered ecosystem management, initiatives must address the full conservation of biological diversity and ecosystem integrity while integrating social and economic demands to the maximum extent practicable. Clear identification of the strategy selected for meeting the ecological objectives as well as the philosophical basis for this strategy is needed to reduce ambiguity around specific initiatives.

Boise Cascade Corporation's ecosystem management projects provide an example of successful implementation of ecosystem management that provides a mechanism to adequately incorporate ecological, economic and social objectives for a landscape. This process uses a coarse filter with an historical range of variability-based approach to address the ecological objectives of conservation of biodiversity and ecosystem integrity. The attainment of ecological objectives has been checked through the development and use of a habitat-based species viability assessment. To be effective, this process requires significant attention to detail in the form of appropriate landscape classification systems, as well as fine scale resolution of maps and attribute data.

Ecosystem management is best accomplished through collaborative, local efforts. These efforts could be enhanced through federal and state programs that would provide funding and technical assistance. Further, enhanced abilities of federal agencies to be directly involved and committed to collaborative, local efforts are needed through modification of existing agency planning legislation. Agency administrators should be cautious about developing top-down guidelines and regional planning programs. Rather administrators should develop guidelines and programs that allow local managers to make the correct resource management decisions. Ecosystem management offers ways for streamlining the currently cumbersome NEPA and ESA processes by addressing ecological objectives at the landscape level and eliminating the need for individual projects to assess cumulative effects.

The knowledge, tools and capabilities exist to implement effective ecosystem management. It is time to move ecosystem management from rhetoric to reality.

Acknowledgments

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The Forest Service's Roads Policy: Assuring Wildlife Habitat Quality

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Three years ago there was a dialogue that the USDA Forest Service had lost sight of its mission. The dialogue was present at congressional hearings and within the organization about the fact that the Service had somehow lost its way. I've got to tell you, I never once believed that.

We were caught in the middle of a significant social debate. The Forest Service was the wrestling mat for the debate over resource management. This agency has been at the forefront of our natural resource management debate for a long time.

We have crafted the natural resources agenda, and I want to thank the leadership of the Forest Service who developed the agenda with me over time. That agenda re-affirmed our focus on ecosystem-based management toward our multiple use mission. It re-affirmed our commitment to our roots, our commitment to caring for the land, our commitment for serving people, our commitment for sustainability, and our commitment to conservation.

This natural resources agenda has four elements: watershed health and restoration; sustainable forest and grassland ecosystem management; roads; and recreation. I no longer hear concerns about a confused mission. There may be those that disagree with the direction, but I hope we have eliminated much of the confusion.

Before I get more detailed about the elements that recreation and road and roadless areas, I just want to tell you how proud I am of the accomplishments of the 30,000 employees of the Forest Service and of our partners in the state agencies, the tribal governments, the NGOs—the people who care about our natural resources and what was accomplished in the past year. We restored 185,000 acres of wildlife habitat, restored or improved 11,300 acres of lakes, treated 87,000 acres of rangeland for noxious weeds, improved 82,000 acres for threatened and endangered species habitat, reconstructed 1,700 miles of trails, reforested 267,000 acres of land, cleaned up 29 major hazardous substance sites. Our research organization published more than 2,700 technical publications, reports and textbooks. Private forestry assisted 11,000 communities; we assisted 2,450 community and volunteer fire departments. About 9.2 million head months of grazing occurred on the national forest. We have 5.2 billion board feet of timber currently under contract. With our sister agencies and partners, we have put out 98.5 percent of our wildfires on initial attack.

You know, that sounds like multiple uses to me. The fact is that the balances are changing, and they have been changing throughout the history of conservation in the United States. Therefore, we've got to be responsive to those changes. Resource professionals need to be leading those changes.

What I'd like to do is step back from the debate for just a couple of minutes, and ask some basic questions. What can we do today to ensure that our forests, grasslands and river systems retain their health, diversity and productivity?

This is our opportunity at the turn of this century to preserve the rich heritage of our public lands legacy and all that it holds for us. How can we work together to ensure that sustainable communities that thrive and prosper in a way that promotes health of the land and social well-being? I constantly ask myself and challenge the employees of the Forest Service with the question, Who's going to want us in 50 years and why?

Perhaps the easiest distillation of the work of the employees of the Forest Service who are located on more than 150 national forests in the country, dozens of research labs and countless communities is that we help the American people live in productive harmony with the lands and waters that sustain us all, and we preserve the rich legacy that we have in the United States.

I talk a lot about watersheds and watershed health. Consistent with our Organic Act, watershed health and restoration remain the oldest and highest callings of the Forest Service. We will continue to make watershed health the overriding objective of national forests and grasslands.

If there is going to be a resource issue in the United States in this century, it's going to be water, and not only in the arid West. Look at the devastation that occurred in North Carolina as a result of the hurricanes and the loss of resilience of the watersheds to be able to deal with those disasters.

The fact is, the cleanest water in the United States flows off of our forests. In fact, about one third of the United States is forested landscape, yet two-thirds of the runoff in the United States comes off of this landscape. If we valued it like we do other commodities, we would have at a minimum $3.7 billion annual benefit from the water that flows off of national forests, which make up about 8 percent of the landscape of the United States.

Now recognizing the essential contribution of national forests and grasslands to water to public sources of drinking water by 2001 in partnership with the states, the Environmental Protection Agency will identify each community that depends on national forest watersheds for their drinking water supply. Each of those will be mapped, and estimates of number of people that they serve will be shown.

Now, directly outside of my window in Washington, D.C. is evidence of success in the of the Clean Water Act. The Potomac River today is a tremendous success story and, in fact, is a tremendous fishery. For one who grew up in the lake country in northern Wisconsin I could never have been convinced that the fishing around Washington D.C. could be as good as it is. The fact that the Bass Masters Classic tournament had one of its best tournaments in history just in recent years on the Potomac River is a testament to the effectiveness and benefits of many of our environmental laws.

Collaborative approaches to restoration I believe are really the future in ensuring that our watersheds, forests, and grasslands stay resilient. I was riding in a vehicle not too long ago with Jay Cravens, a Forest Service retiree, and I said to him, "Jay, how do you think I'm doing?" Knowing Jay, I was sort of expected a lecture. He said to me, "Mike, if we take care of the soil and the water, everything else will be okay." That is a core message that we need to take everyplace we go.

In fiscal years 2000 and 2001, the Forest Service will invest more than $18 million to implement 12 large-scale collaborative watershed restoration projects covering more than 15 million acres. This is in a direct response to many of you in this room who talked about the need for a more holistic, ecosystemwide, watershedwide approach as we deal with the various challenges that we have on the landscape that go beyond the practice of individual disciplines.

I want to talk a little bit about sustainable forest and grassland ecosystems before I get into roads. The U.S. is an increasingly developing nation, and if we take a look at the statistics of urban sprawl, and fragmentation of our large tracts of land, it's a scary sight. More than 16 million acres were developed from 1992 to 1997, for example, and that's double the rate of the preceding decade.

What we have in our national forests is a tremendous bounty of large tracts of land. The national forests are biologically diverse. They are the anchors of many threatened, endangered or otherwise rare species. By having these lands, pressure is taken off private lands.

Our understanding of the natural processes continues to improve because we have the best science in the world. We need to apply that science. I think of an issue such as fire. The fact is, we got so good at fire prevention that we put every fire out every time we could—even the beneficial ones. Of course, our landscape started to lose diversity as a result. We were losing the mix, and mosaic of early, mid- and late seral-stage habitats on which the diversity of wildlife depends.

The second thing that happened was that we increased the fire risk in many of our mature forests, as well as in the urban/wildland interface. We're also dealing with issues of introduced pests, animals and plants that compromise the biological diversity that often outcompete the native fish, wildlife and vegetation. That, compounded with the absence of fire and variety of other outdated management practices, gave us significant challenges.

On the national forest, we have 24 million acres at high risk of fire. We need to turn that around. That's the objective of the large-scale watershed projects.

The prescriptions must be based on science. The suite of treatments may be very diverse and include leaving something alone to allow it to heal, stabilizing roads or decommissioning roads to deal with noxious weeds thinning fuel treatment and utilizing wood to meet the ever-increasing fiber demands wherever possible. That simply makes good economic sense, and it makes good environmental sense.

Many now argue for the need of a zero cut on public lands. I reject that notion. I believe it is inappropriate for the wealthiest nation to rely on timber products from lands and nations that have less environmental protection.

The national forests ought to serve as international models of sustainable forestry where practices not only help meet the nation's needs for wood, they improve habitat conditions for wildlife populations, and will work while moving forward with stewardship oriented timber harvests to remove some of the low value wood that reduces fire risk. Work to encourage businesses, encourage research and communities to transitions to provide jobs in new areas. Because without this kind of commitment, the private sector and Congress are less likely to invest in the land that's so important to all of us here.

Let's focus on our roads and roadless areas. This year we're going to continue to provide leadership and attempt to resolve the divisive issue of both roads and roadless. We've accomplished a lot in this arena.

First, I want to talk about roads. We've published a new science-based analysis procedure to assist managers to make better decisions about roads. That's available, and my hope and belief is that this document—a synthesis of the best science we have on roads—will be utilized by county commissions, large landowners and many individuals to whom we provide information, to ask some real important questions as we move forward.

The second thing that is going on with the road policy is that there is a road policy out for review. We hope to issue a final of this policy late this summer. The team leader is Dale Bosworth, Regional Forester from Missoula.

The national roads policy focuses on the roads system of the future, rather than the current struggle over a crumbling or, maybe more appropriately said, eroding roads system that we can't afford to maintain. The policy provides a framework for local governments and local communities to work with Forest Service managers about the decisions of the future of the national forest roads system.

They will address issues such as which Forest Service roads are of high priority? What are the lower priority roads? Are there roads that are no longer needed? What should be done with those roads? Should they be closed or decommissioned? Are they bleeding sediment in the streams that need to be dealt with? Should they be converted into hiking trails, biking trails, hunter walking trails? What is the best use of that system? Decisions will be made with local Forest Service employees in and around the national forest and the communities of interest.

It is important that the Forest Service road system mesh with the local community roads system to best meet the needs for forest management as well as the transportation needs of that community. But the bottom line is that we have to have a road system that we can afford.

That gets me to the money part of what I want to say. When you have 380,000 miles of roads, and you have an $8 billion backlog in maintenance and re-construction, what do you do? If you're a private landowner, and you own this land, what do you do? Particularly with the acrimonious debate in the Congress over this road system.

Roads system was really used as a surrogate for the timber debate, particularly the debate about whether to enter roadless areas. I think the temporary moratorium on road building in roadless areas helped to move that debate forward. Because for the last two years, we no longer see this debate over funding of the Forest Service road maintenance budget.

That budget is now increasing. We will be successful on this roads front when we have this roads program funded to the tune of say $200 to$ 400 million dollars a year. We're working with Congress and the Federal Highway Administration to accomplish that.

Now for those who are concerned about access, the reality of it is—as Jim Lyons and I have said—this probably should be referred to as "access initiative." When you're not maintaining a system, you're losing access. Of the nearly 90,000 miles of arterial and collector roads the hard surface roads on which you can drive a two-wheel drive vehicle—we're losing about 1,000 to 1,200 miles a year because of lack of maintenance. We are having to reduce weight limits on bridges and are unable deal with washouts and landslides.

To get this infrastructure funded and maintained appropriately is one of the most significant things that those who love to be in the woods hunting, fishing, hiking, biking, driving or whatever you do is most important. We need your support for that access initiative.

Let me talk about the more challenging issue for a minute now. That's the thorny issue of roadless areas.

The 54 million acres of roadless areas that we have in the United States in national forests are the strongholds of many wildlife species that require large home ranges. They're the strongholds of many of our aquatic species that are in trouble. Fire risk is much lower there than areas that are already roaded. The incidence of noxious weeds and invasive species is much less than in areas that are already roaded. How is it that we can serve these values embodied in roadless?

The reason that we have these areas is really a tribute to those who came before us, those who reforested much of the East, Northeast and South, and those who protected many such areas over the years in the West. This is a legacy of which we should all be proud. It also is a legacy that is very important for future generations.

Now it's our turn. It's decision time for roadless—time to ask ourselves what is it that we want? What you will see in mid-May is a draft environmental statement that will lay out alternatives which likely will be everything from no action to a form of reduced development in roadless areas, but primarily focusing on the question should we have permanent road systems in the remaining unroaded landscape on the national forests is the primary question.

The second set of issues that we are looking at in roadless have to do with the roadless characteristics that are important to people and local communities, people that hunt, fish, hike and bike and enjoy the national forest. Those decisions will be made at the local level. Guidelines will be provided that provide to the protection of drinking water supplies, other values that are important to local people.

Now there's been a concern about the data. There will be two rounds of public meetings associated with the roadless issue. Two meetings on every national forest, plus the typical national meetings that we do. The first will lay out the data, the economics, have all the maps with all the lines on the maps to identify the roadless areas, explain what they are. We want people to take those home, digest them, visit with their neighbors about what this is all about, what values are important. Then the second round of meetings will focus on their concerns, issues and desires associated with what the future of these roadless areas should be.

There are those that say much of this is occurring someplace else. I've got to tell you, the administrative rule making process is one of the fair and most open democratic processes in the United States, because it puts the same information base in everybody's hands. Whether you're an executive of a timber company, a recreation concern, a federal employee, or somebody that just likes to hunt, fish, hike and bike. It puts everyone on an equal plane, and you need to be involved in that.

Let me just spend a couple of minutes talking about recreation. Despite the rumor around the country that we're reducing access on national forests, more people are using the national forests, using more kinds of equipment and going places they've never gone before than ever before in history. They don't have to worry about no trespassing signs. These lands are open. You can set up a tent anyplace for two weeks, and you don't have to pay. You want to pay: Go to a campground. That is the access available, and we anticipate no change.

Any of those decisions, whether to add a road to the road system or whether to remove a road from the road system will be made through the local forest planning process.

Given the 860 million recreation visitor-days on national forests, we face significant challenges to get the funding to provide the infrastructure, the interpretive services needed for recreation on the national forests. We have a strategy that is being developed. We had a national summit. There are recreation summits for stakeholders and others occurring throughout the country as we speak. We are really focused on six key areas based on feedback from those so interested in recreation.

Number one is that we've got to know the people that we serve better. We find this out through sociological studies to market analysis of what we do. We must invest in the special places that are important to people. This is about taking care of our infrastructure, and roads are the highest price tag item of this infrastructure that we have.

We have to reduce our maintenance backlog not only of roads, but of our entire recreation infrastructure.

We want to focus more and more on partnerships. Partnerships in the wildlife and fish community have led the way, starting out with a challenge cost-share program and many others, and now we have to move this to the area of recreation.

We need got to develop business opportunities for underserved and low-income communities, some of which are stressed because of the changes in balance that are going on in regard to timber harvests and other pursuits on the national forests.

We must improve access to the public lands, within the limits of the land. Pursue rights of way and other means to assure that people do have access to the national forests.

I want to say that owners and the visitors to the United States are welcome to the national forests. And visit you do, to the tune of 860 million recreation visitor-days a year. We expect it to exceed 1 billion. I invite you to enjoy camping at some of the 4,300 developed campsites. Recreate at the more than 23,000 developed recreation sites on the national forests. Strengthen the bonds with your families and your friends. Spend time together. Improve your health. Hike and bike 133,000 miles of trail on your national forests. Perhaps you enjoy driving—the most popular use of national forest roads. We've got 7,700 miles of scenic by-ways from which to enjoy nature. Or maybe you like to fish. Half of the blue ribbon trout streams in the United States are part of this heritage. Think of the thrill of fishing a blue ribbon trout stream. Enjoy turkey hunting. Perhaps a family wilderness experience on an elk hunt that will be etched on the memory of your children. This is the heritage we have.

In closing, I have a request of everyone here—take this message to everyone you know. It's more than a request, it's a plea to engage the hunters, anglers, the hikers, bikers, campers, other recreationists, commodity interests, the recreation industry, all that care about this 192 million acres. These are <u>your</u> lands. The Forest Service is <u>your</u> agency. Taxpayers pay us to work for you.

All the best science, the political posturing, the interest group tussles in the world will not replace the will of the people. You in a democracy are empowered to assist. Engage us. Make your views known, and help us ensure that we pass on to our children this tremendous legacy the we have inherited. And let's make it better.

War on Weeds: Winning It for Wildlife

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I am honored and privileged to be here with you today to discuss the rapidly accelerating damage that invasive plants are inflicting on wildlife habitat in this country. This problem may seem overwhelming but you need not despair, because there are economical, realistic and effective strategies available to meet this challenge.

There are two purposes to this presentation—to show how wildlife habitat in thousands of public land watersheds is rapidly undergoing the greatest permanent degradation in its recorded history, and to suggest that we must engage enough of the right people to win the war on invasive non-native plants.

I would like to begin with a reminder of our basic land management goal which is to maintain or improve the health of the land. This goal really means striving to have a wide variety of healthy grasses, forbs, shrubs and trees distributed across the landscape. Fortunately, well managed land is the best defense against the spread of weeds. The best way to rate the health of a plant community is by determining the percentage of exotic species present (Fegler 1998). Unfortunately, when we look at the vast public lands in the West, the greatest obstacle to maintaining healthy plant communities and to the restoration of less than healthy communities is the rapid expansion of invasive weeds. Invasions are easy to recognize in hindsight after they have entered an explosive phase. Unfortunately, by this stage, it is difficult or impossibly expensive to control the increase of the invader (Huenneke 1996). An example is The Nature Conservancy's Altamount Prairie in South Dakota which is so badly infested with leafy spurge that it is no longer regarded as worth managing as native prairie and cannot be sold as cropland (Randall 1996).

I will be showing some ugly pictures of severe weed infestations because I believe they best illustrate the problem and because we need to develop foresight and learn from our experiences. There is absolutely no criticism intended. I will refer to exotic, alien, noxious, invasive and non-native plants as weeds.

Permanent Degradation

There are many exemplary weed management efforts underway by private, county, state, university and federal organizations. To the credit of many dedicated people, the number of successful restoration projects increases every year. However, the amount of wildland being restored is minuscule compared to the amount of land that needs to be restored. Therefore, the term "permanent" is used because, with today's economics and technology, it is impractical to restore most extensive weed infestations, especially in steep or rocky terrain. Furthermore, extensive weed infestations near trees and shrubs, and infestations in riparian areas frequently become permanent because of restrictions on the use herbicides in those areas.

Let's discuss four examples of extensive land degradation that represent hundreds of others. These examples show how many more wildlands will move into this category of permanent degradation—if we allow that to happen.

In 1938, Clarence Seeley, from the University of Idaho, made his first identification of yellow starthistle just north of Lewiston, Idaho. Although its danger was not recognized then, this plant now infests hundreds of thousands of acres in that region, including an estimated 30 percent of the BLM land in the Cottonwood Resource Area (L. Wilson personal communication: 1994). In 1993 in Oregon, explosions of yellow starthistle were reported, with more than 100,000 acres in Jackson county and 200,000 acres in Umatilla county. Now both counties report that those populations have doubled!

In 1970, there were about 32 acres of leafy spurge in the Theodore Roosevelt National Park in North Dakota. Herbicides were not allowed and now leafy spurge dominates more than 4,000 acres of the park (Andrascik, 1997). There are more than 1 million acres of leafy spurge in North Dakota and 600,000 acres in Montana. Extensive infestations of leafy spurge also continue to spread in Wyoming, Idaho, Colorado and Oregon.

From just a few plants in western Idaho in 1954, rush skeletonweed now infests more than 4 million acres—"an explosion in slow motion"—and has leapfrogged 100 miles to the east, beyond Shoshone, Idaho, and to the west into the Hell's Canyon National Recreation Area along the Idaho and Oregon border. Severe infestations of rush skeletonweed also are spreading rapidly in California, Washington and other parts of Oregon.

In the early 1960s, perennial pepperweed began arriving in the Ouray National Wildlife refuge in Utah. Today, it dominates about one half of the bottomlands in that refuge (D.Schaad personal communication: 2000).

Impacts

There are major impacts of invasive weeds to wildlife habitat, watershed health and endangered species. Studies in Montana show that spotted knapweed invasions reduced available winter forage for elk between 50 and 90 percent (Duncan 1997) and, in some parts of Theodore Roosevelt National Park in North Dakota, leafy spurge reduced bison forage by 83 percent and deer and elk forage by 70 percent (Stalling 1998).

Wildlife habitat in riparian areas is especially vulnerable to devastation by weeds because of the extra moisture for plant growth and the easy transport of weeds into riparian areas by people, animals and water. Perennial pepperweed, leafy spurge, Russian knapweed and tamarisk (salt cedar) often form near monocultures in riparian areas and adjacent uplands. Purple loosestrife is another exotic that thrives in riparian and wetland habitats. In its native habitat in Europe it only comprises 1 to 4 percent of the native vegetation, but in North America densities of up to 80,000 stalks per acre have been recorded (Strefer 1996). Thus, purple loosestrife outcompetes native plant species and reduces biodiversity (Nyvall 1995).

Tamarisk, a deep rooted shrub or small tree, can consume as much as 800 liters of water per—10 to 20 times the amount used by native species it tends to replace (Cooperrider 1995). Tamarisk commonly draws water levels down so completely that small springs and streams cease flowing. This has a dramatic effect on native vegetation, wildlife and rare plants. As tamarisk displaces native vegetation, the value of the habitat for animals is markedly diminished.

Fibrous rooted native plants hold soil in place, reduce erosion, promote infiltration and safe release of water, and provide resilience against fire and drought. Many invasive weeds, in contrast, have primarily a tap root that does not have those beneficial characteristics. In a study area in Montana, runoff and sediment yield were 56 percent and 192 percent higher, respectively, for areas dominated by spotted knapweed than for native bunch grass vegetation types (Lacey 1989). That increased runoff, early in the season, results in lower summer flows with higher stream temperatures. This lower temperature, coupled with increased sedimentation, degrades water quality and fish habitat.

Numerous studies demonstrate reduced numbers and/or diversity in birds, reptiles, small mammals, and insects in stands of non-native plant species (Huenneke 1996). For example, kangaroo rat and ground squirrel populations were severely reduced on sites infested with Russian knapweed in a study in Wyoming (Johnson et. al. 1994).

Four vegetative characteristics commonly used to evaluate wildlife habitat quality include: horizontal plant diversity; vertical plant diversity; amount of edge; and the degree of interspersion. As weed infestations become severe, diversity declines and wildlife habitat quality degenerates (Olson 1995). Research concerning chukar partridge habitat use and availability in the severely infested lower Salmon River Canyon of Idaho, revealed that chukars selected against (avoided) habitats with higher yellow starthistle ground cover (Lindbloom 1998). Another study showed that when chukar partridge were given free access to all the medusahead caryopses (seed) they could eat, along with other dietary requirements, they suffered dramatic losses in body weight (Savage et al 1969).

In a study just 25 miles from here (Chicago airport) at the Morton Aboretum and the Hidden Lake Forest Preserve, exotic shrubs appear to be an ecological trap for songbirds. Significantly higher nest mortality to American robin and wood thrushes was observed in bush honeysuckle and common buckthorn, in comparison to mortality in native plants. This is probably due to a combination of sturdy and low branches for nest building, early leaf flush that attracts birds, and the absence of sharp thorns that would otherwise inhibit large mammal predation (Schmidt et al. 1999).

The impacts of weeds upon wildlife habitat are not restricted to public lands. For example, in 1988, a 1,300-acre ranch near Klamath Falls, Oregon, was abandoned due to leafy spurge infestations. The ranch then was purchased at an auction for about 10 percent of what it would have sold for otherwise (Humphrey 1988).

Here in the Chicago area where there is an extensive system of preserves, approximately two dozen invasive plant species are currently causing serious and sometimes devastating damage to natural areas. These plants are reducing native plant diversity, and thereby associated animal diversity, by successfully competing for space, water, sunlight, and nutrients. The spread of these species is recognized as a direct threat to natural communities and to some endangered species. It is arguably the greatest single threat to the integrity of the flora and fauna of the Great Lakes Region (Chicago Wilderness 1999).

The impact to endangered species is significant. On U.S. Bureau of Land Management (BLM) managed land, there are currently 236 federally listed species, 50 proposed for listing and another 1000 plant and animal species in the sensitive category (Lawton 1999). For example, in nine states having long term data, breeding sage grouse populations have declined by 17 to 47 percent from the long-term average (Connelly et al. 1997). Sage grouse need a wide variety of grasses, forbs and shrubs for foraging and nesting. However, on BLM lands near Idaho Falls, leafy spurge is forming a near monoculture—taking over some critical grouse habitat.

Another example of impacts to wildlife is the Chinese tallow tree which continues its rapidspread from North Carolina to Texas with new starts in California. With its capacity for rapid growth and prolific reproduction, tallow is capable of converting native prairies into near monoculture forests in only a few years (Grace 1998). The endangered Atwater prairie chicken in Texas requires open prairie but unfortunately the tallow tree has already, and continues, to take over much of the prairie chickens habitat (M. Williams personal communication: 1999). Similarly, the endangered whooping crane needs the open ponds and adjacent uplands on the Aransas National Wildlife Refuge and adjoining lands in Texas. Here again, the tallow tree is invading this critical habitat (T. Stehn personal communication: 1999).

Looking at a larger perspective, I do not know of any weed that is all bad. For example, many bird species like tallow seeds. So there is some benefit from this tree. However, regarding insectivorous migratory birds, research shows that there are significantly less insects on tallow than on the native oak. Furthermore, while caterpillars are an important food source for migrant birds, caterpillars cannot be found on the exotic tallow tree. Caterpillars are, however, abundant on native trees and other plants (W. Barrow personal communication: 1999). Also, foraging migrant birds, as a group, avoided tallow trees (Barrow et al 2000). So, while there is some value to the exotic tallow tree, like other invasive exotic plants, it commonly grows into extensive monocultures, especially after fires, floods or hurricanes. Each wildlife species has specific habitat requirements for feeding and cover—which are different for different animals. Therefore, instead of monocultures of weeds, the native vegetation must be diverse to support the full wildlife community.

Rate of Spread

Why did I say that wildlife habitat in thousands of public land watersheds is rapidly undergoing the greatest permanent degradation in its recorded history? It is because so many lands are in the *process* of becoming infested. Wildland weeds increase on average about 14 percent per year which is an exponential doubling every five years. In one research area in Colorado, dalmation toadflax increased 1,200 percent over a six-year period (Beck 1998). Similarly, field inventory data in the South Fork of the Shoshoni drainage in northwest Wyoming showed that dalmation toadflax increased from four acres in 1985 to 2,000 acres in 1997 (Christy 1998). These data are supported by observations of BLM employees in Prineville, Oregon, who for many years have taken a management trip during the first week in June through wilderness study areas along the Lower John Day River. In 1996, they returned from the trip reporting that the dalmation toadflax populations had doubled in size from 1995. Following their 1997 trip, they reported that the toadflax had doubled in size again.

Detection surveys in the Renne watershed on BLM land near Worland, Wyoming, show that hoary cress increased from 14 acres in 1990 to 2,000 acres in 1995 (Christy 1998). Similarly, in the Keating Valley of eastern Oregon, hoary cress was confined to very small patches in the farmland 15 years ago. Today hoary cress extensively dominates nearby critical deer winter range on BLM lands.

There were only minor populations of spotted knapweed in Montana in 1920. Today, there are about 5 million acres with another 29 million acres of highly susceptible land in that state alone (Duncan 1997). Spotted knapweed also is expanding rapidly in Wyoming, Idaho, Colorado, Oregon and California.

Invasive weeds are a major issue in the Interior Columbia Basin Ecosystem Management Project Draft Environmental Impact Statements (EISs). Many scientists worked on those documents that cover portions of seven states. Quoting from one EIS: "Weeds are spreading rapidly, and in some cases exponentially, in every cluster and 66 percent of the BLM/FS lands are susceptible to knapweed and yellow starthistle" (U.S. Department of Agriculture/U.S. Department of Interior 1997). And, 16 years ago, yellow starthistle infested about 1 million acres of private and public land in California. Today, population estimates range up to 15 million acres (R. O'Connel personal communication: 1998).

Now a local example. A study on the Middlefork Savanna Forest Preserve, about 25 miles northeast of here (Chicago airport), showed that common buckthorn increased about 650 percent between 1986 and 1996 (Bowles et. al 1996). Considering a broader view of this region, in eastern North America, garlic mustard increased exponentially between 1929 and 1989, with the number of new occurrences approximately doubling every 20 years (Nuzzo 1993).

These examples may seem like a lesson in history. However, this massive habitat degradation will only accelerate in the future—if we allow that to happen. Like human populations, weeds typically increase exponentially, beginning slowly, then doubling and redoubling (Kummerow 1992).

Fire and Rate of Spread

Weed populations can flourish following fire. Wildland fire is a natural process that often helps to maintain or improve the health and productivity of native plant communities. I fully support appropriate prescribed fire. However, when exotic plants are involved, fires burn in an unnatural situation and weeds commonly explode following fire. Fortunately, there is usually a unique window of opportunity to control the weeds following fire and before "seed set" because weeds are especially vulnerable to control at that time.

In a research example from northern Utah, wildfire increased squarrose knapweed abundance by 50 to 120 percent within just two years. Control of squarrose knapweed by applying herbicide in the first fall after a summer burn was 98 to 100 percent effective, while the same herbicide treatment achieved only 20 percent control or less in adjacent non-burned areas. Not only did this study show that invasive weeds can increase dramatically after a fire; but it also shows that post-fire herbicide application is a unique window of opportunity for effective control (S. Dewey personal communication: 1999).

Postpfire weed increases can be found in a variety of environments. Near Tintic Junction and Perry, Utah, pictures of fire line contrasts between burned and unburned areas make it obvious that when squarrose knapweed or dyer's woad are a minor component of a plant community those weed populations often explode after fire. When Pat Fosse, with the BLM in the Fillmore (Utah) Field Office, studied the nine major weed infestations in her area of responsibility, she found that all of those weed infestations are in areas that have burned recently. In the Sellway Bitteroot Wilderness in Idaho and Montana, spotted knapweed frequently becomes the dominant plant after fires (D. Dailey personal communication: 1993). Dalmation toadflax exploded recently after wildfires in parts of Yellowstone National Park. Similarly, a few musk thistle plants were noticed in 1995 in a woodcutting area on BLM land near Montrose, Colorado. Following a wildfire in 1996, musk thistle populations now form near monocultures over large areas. Where there were only a few plants of hoary cress in 1996 before the Broken Back fire on BLM land near Worland, Wyoming, there is now a major population of this noxious weed (Christy 1998). Accelerated by wildfire, yellow starthistle now infests about 25 percent of the Forest Service Ishi Wlderness in northern California.

In the BLM Sand Butte and adjoining Wilderness Study Areas in Idaho, considerable weed surveillance had been underway for many years. Until a huge wildfire burned over the area in 1992, rush skeletonweed infestations were not known to exist there. In 1995, a few rush skeletonweed plants were found and controlled. In 1996 the entire area burned again. A detection survey in 1997 found serious rush skeletonweed infestations scattered within a 60,000-acre area.

One indication of how these weeds can be so competitive after fire is shown in a series of pictures of squarrose knapweed, diffuse knapweed and rush skeletonweed sprouting and setting seed within five to eight weeks after fires. These weeds promptly produced their second crop of seeds while all other plants were dormant, awaiting another season to arrive.

Sonoran Desert

The unique disaster unfolding in the Sonoran Desert deserves special mention because unprecedented and unnatural wildfires are destroying native plant communities. Within the last seven years, destructive wildfires have consumed large tracts of some of the most scenic and species-rich parts of the desert. Red brome, an exotic annual grass, grows in dense stands providing abundant fuel between the widely-spaced native plants. Red brome grows back more vigorously after fire, and with more red brome, there's more fire—an accelerating self-perpetuating fire cycle (Schwalbe 1999). Even though some plants resprout, populations of most native perennial plants are catastrophically reduced or eliminated, especially after repeat fires. Many mature saguaro cacti and most young saguaros are often killed with a single fire. Smaller cacti such as pincushions, hedgehogs, prickly pear, and all species of cholla, and palo verde trees are also usually killed. While the damage from red brome (and to a lesser degree other non-native grasses) is already extensive and landscapes are permanently altered, this is only the beginning of the degradation that is set to occur on a grand scale (Asher 1999). Experts in Sonoran desert ecology have this to say:

- "In the Sonoran Desert, many species of perennials that are burned are unable to resprout
  from underground parts following fire" (McAuliffe 1997).
- "Perhaps the most serious problem created by the spread of exotic annuals has been the resultant increase in fine fuel and fire frequency, particularly in arid regions" (Schmid et al 1988).
- "At several locations in the Sonoran Desert, fires accidently ignited by motorists have eliminated saguaro and many other desert perennials over large tracts adjacent to roads" (Rogers 1985).
- "The propensity of dried red brome to carry fires may lead to the elimination of much of our Sonoran Desert as we know it" (Haughey 1997).

There are many serious biological threats to the Sonoran Desert but by far the greatest is the clear potential for red brome (and other exotic grasses) infestations and the resultant wildfires to transform much of this desert into vast wastelands with minimal wildlife habitat value. Of the four deserts in North America, the Sonoran Desert is by far the richest in number of life forms and in variety and development of plant communities (Shreve 1964). The danger to this biotic treasure, so cherished by the American public, is imminent. All one needs to do is look north in the Great Basin where cheatgrass invasions (a close relative of red brome) are blamed for about 1.7 million acres of wildfire in 1999 (U.S. Department of Interior 1999).

Unlike most of the other seriously invasive weeds, we don't know how to control the spread of red brome in wildlands. Therefore, there is an imperative and an immediate need for a major research symposium, tapping the best minds in the world, to develop prevention and control strategies. Such a symposium should be sponsored by an organization capable of ensuring significant and long-term funding for this complex research.

Urgency

Looking at the big picture, the Departments of Agriculture in 11 western states estimate that there are about 70 million acres of invasive exotic weeds on private, state and federal wildlands. This means there are 70 million acres of weed seed being produced every year, much of it being carried to other wildlands by wind, water, wildlife, livestock, people and equipment. Consequently, just as lightning can strike anywhere, no public land is immune from attack by these weed seeds. Therefore, we need to look beyond known weed infestations and cooperatively keep a vigilant watch on all lands that are susceptible to weed invasion.

How urgent is it to control weeds, especially small infestations? First, we need to remember that, unique among environmental degradation problems, weeds are self-multiplying. They don't stop at some point like wildfire, nor do they deteriorate over time like chemicals. Second, severe and extensive weed infestations begin with just a few plants. Therefore, the thousands of small and/or new infestations currently growing out of control on relatively uninfested land, truly constitute a state of biological emergency.

Solutions

With big game, bird, fish and endangered species habitat undergoing rapid, accelerating and often permanent degradation from weed infestations, on a grand scale, what are the solutions? The magnitude of this problem can leave one feeling overwhelmed. But, if we had just discussed wildlife management, or recreation management, everywhere—all at once—like we just discussed weeds, we also would feel overwhelmed. However, at the local watershed level where someone is responsible for every piece of land, cooperative weed management can be a reasonable, effective and rewarding endeavor. About 90 percent of the 350 million acres of western public lands, are not significantly infested — yet. And, there is a readily available, effective and widely accepted strategy called Integrated Weed Management that includes: prevention, education, detection, control, restoration and monitoring. However, to be effective, cooperation among all landowners, user groups and agencies is critical. That is why cooperative weed management areas are so urgently needed in so many landscapes. A county, state and federal effort produced the *1999 Guidelines for Coordinated Weed Management: Development of Weed Management Areas* (available from regional Forest Service and state BLM offices). These guidelines can help people learn how to initiate and implement cooperative weed management areas.

The biggest key to winning the war on weeds is to put top priority on keeping relatively uninfested land from becoming seriously infested. In conjunction with all the other Integrated Weed Management Strategies, this is an effective, economical and realistic approach. Together we can do this all over the country, but we must engage enough of the right people to at least be planning to win this war —with a campaign commensurate to the threat. For this to happen our sense of urgency must escalate dramatically. More specifically, thinking about the organizations represented here today, I have some proposals for you to consider: (1) make exotic plant management one of your top organizational priorities; (2) designate a lead person at all levels of your organization to develop policy, funding, and to weave weed management into every day activities; (3) make weed management a top priority habitat management responsibility for wildlife biologists—along with forestry, fire, wilderness, recreation, range management and minerals people.

Here are just three examples of what would surely happen "on the ground" if you implement these three suggestions along with other ideas you may have: First, in 1992, Dave Weber, habitat biologist for the Colorado Division of Wildlife (CDOW), began cooperatively attacking purple loosestrife infestations in the Denver area. In cooperation with numerous local governments, Weber provided the leadership for detection surveys and fairly comprehensive control work every year in three drainages. As a result, in 1998, in 31 of the 130 original sites, purple loosestrife can no longer be found. On the remaining ninety nine sites the seed heads are being cut and purple loosestrife is being controlled. Consequently, there has been a drastic reduction in the amount of loosestrife seeds floating out of the Denver area. Furthermore, Dave publishes the "CDOW Weed News," and is a key organizer of the Colorado Weed Network.

Second, every year in the Carrizo Gorge Wilderness in southern California, Tim Finger, BLM wilderness coordinator, leads a group of Sierra Club volunteers and Civilian Conservation Corps workers to search out and remove tamarisk. The tamarisk dries up water in small streams and springs. The water that is critical to the threatened Peninsula bighorn sheep, frequently flows again following removal of tamarisk.

Third, giant reed continues to take over habitat for endangered fish and birds in southern California. Research shows that the total number of insects, total insect biomass and taxonomic richness of invertebrates associated with giant reed are significantly lower than that associated with native vegetation (Herrera 1997). Furthermore, giant reed uses about three times as much water as the native plants, introduces an unnatural fire cycle into the ecosystem and easily replaces entire plant communities (Iverson 1993, Bell 1993, Reiger and Kreager 1989). Shawna Bautista, wildlife biologist on the Angeles National Forest, initiated, secured outside funding, and now coordinates many giant reed control projects.Thanks to Bautista, pictures show the dead reed with native willows returning.

These three people view weed management as a critical part of their habitat management responsibility. These examples show what can happen in thousands of other places all around the country if high priority is given to weed management and if wildlife biologists, along with other specialists, see weed management as one of their top priority responsibilities — to protect and enhance wildlife habitat.

Finally, the people that can have the greatest influence in setting weed priorities high enough, along with the commitment for full support, are those gathered here in this room today. I urge you to act quickly and decisively while we still have the opportunity to prevent wildlife habitat, in so many watersheds, from entering that category of permanently degraded.

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1999 National 4-H Wildlife and Fisheries Volunteer Leader Recognition Awards

Many children who have taken part in and learned from 4-H educational programs have become life-long stewards of natural resources. Some have chosen a career as natural resources. Some have chosen a career as natural resources professionals due, in no small part, to the mentoring provided by these volunteer leaders. Many others eventually have become volunteer leaders themselves; in fact, many of this year's winners were involved in 4-H as youngsters.

These six winners were selected from a list of impressive state winners. Nationwide, this cadre of more than 625,000 volunteers contribute more than 137 million hours of their time annually. These winners represent the cream of the crop, the best of these many people who give, not just of their time and resources, but of themselves to help youth conserve and protect our natural resources through the 4-H Wildlife and Fisheries program. Teaching our nation's youth about natural resource stewardship is one of the highest priorities that any of us involved in natural resources management can have.

Collectively, the winners collectively have contributed more than 110 years of service to 4-H volunteer leadership efforts, and CSREES is proud to have the opportunity of partnering with the U. S Fish and Wildlife Service to recognize them for their exemplary leadership and contributions.

PATRICIA MIOLEN

Patricia Miolen, from Newnan, Georgia, grew up on a dairy farm where she was fortunate to be able to appreciate and interact with nature from early childhood. Patricia was involved in 4-H as a child and then became re-involved when her own children reached 4-H age. She has since served as a volunteer leader for 31 years. Patricia is committed to and has been very involved in youth education with both Scouting and 4-H youth programs. She has developed natural resource curricula for public schools, trained other 4-H adult leaders and coaches, and served on a committee to develop an outdoor classroom for the local elementary school. In addition to her other numerous activities, Patricia also has been involved in fund-raising activities for 4-H programs, working with associations in conducting fishing tournaments, helping 4-Hers learn hunting, fishing and fur trapping skills. She also takes club members to state and national conservation conventions, such as the National Wild Turkey Federation Convention.

Patricia says that the Wildlife Habitat Invitational contest is one of her most enjoyable activities. She finds it very rewarding to take kids who have never been off the sidewalk, introduce them to a world that she knows and loves and observe their growth in knowledge, skills, appreciation and understanding of natural resource conservation and ecological principles.

DAVID R. GREER

David Greer is a high school science teacher from Danville, Ohio, in Knox County. He is a former university administrator who returned home to resume his original career of teaching; he almost immediately became involved in 4-H. David had been involved in 4-H as a youth but had been away from the program for many years until his return to Knox County in 1985.

After becoming reconnected with 4-H, he quickly became deeply involved. He served as the volunteer statewide coordinator during the time when Ohio was just entering the Wildlife Habitat Evaluation Program. He facilitated coaches workshops, developed educational materials, presented informational and recruiting activities and conducted the statewide competition. In addition, he has provided leadership for other natural resource programs including the Master Conservationists Program, the Coverts Workshop and the Woodlands for Wildlife Program.

David plans to increase his 4-H involvement, especially in a couple of years when he retires from his teaching job. One of his goals is to bring the National Wildlife Habitat Evaluation competition to Ohio and expand 4-H youth involvement in natural resource projects and programs across the state. He is a science teacher by vocation, but his avocation is youth development and he has served as a volunteer 4-H leader for 15 years. David says his avocation as a 4-H youth leader has increased his understanding and appreciation of conservation immensely, and he is committed to passing this on to 4-H youth in the future.

VIRGINIA WHITTINGTON

Virginia Whittington is a self-employed, floral designer from Vicksburg, Mississippi, in Warren County, who has served for more than 28 years as a 4-H volunteer leader. She is the mother of three former 4-Hers and currently has four grandchildren in the program. Virginia became involved in 4-H when her own children were in 4-H. When her children grew up, married and left home, she continued her 4-H involvement as a volunteer leader. She believes her 4-H involvement helped her gain a greater knowledge in many fields of study and enjoys helping others share this experience. Virginia particularly enjoys seeing her 4-Hers grow up, go on to college, have successful and enjoyable careers and become good, responsible citizens.

Virginia has been involved in almost every conceivable aspect of 4-H including: wildlife, fishing, shooting sports, trapping, boating, canoeing, camping, cast iron cooking . . . . You name it, she has probably been involved with it, providing leadership, guidance and encouragement to her 4-Hers. One area of particular note has been her involvement with the Instructor Corps Program at Tensas River National Wildlife Refuge. In this program, she has helped train high school students to become environmental education instructors for the Refuge. Of the 33 students who have completed the program, nine came from Virginia's 4-H program.

Virginia is firmly convinced that young people who become involved in learning about resource conservation through hands-on educational programs will become better citizens and better stewards. We agree, Virginia, and thank you for your personal commitment to these young people.

JIM LEET

Jim Leet is a senior collections officer for the State of Alaska, Division of Investments, in Juneau. He became involved in 4-H about 12 years ago when his daughters were 4-Hers. As so often happens, he started by helping out a little—in his case with woodworking—then, over time, becoming more involved. Now, 12 years later, Jim's daughters are grown and off to college, but he is still active in leading 4-H natural resource educational programs.

In achieving his mission, Jim has drawn heavily on the talents of other people, agencies and organizations, such as the Alaska Department of Fish and Game, Ducks Unlimited and others in the Juneau area. He has not been reticent to ask other talented people to help out and, in doing so, has greatly expanded the horizons of 4-Hers in his charge. In 12 years of 4-H leadership, only three people who were asked to help out have declined.

In the future, Jim wants to continue to expand his efforts in fishing-related activities and to help to get more volunteer leaders involved in mentoring the young people. He also wants to build bridges between 4-H and other natural resource groups to help provide opportunities for the young people to become more actively involved in conservation projects. Jim says his most rewarding recognition comes from observing his 4-H'ers become solid citizens with an appreciation of wise stewardship and a commitment to passing their knowledge on to future generations.

KATHY WORKMAN

Kathy Workman is a 4-H volunteer leader from Delano, Minnesota, who also grew up on a dairy farm and was involved in 4-H from an early age. Kathy says she has been interested in natural resources stewardship from her earliest recollections. As with many of today's 4-H volunteer leaders, she returned to 4-H when her own children reached 4-H age. Kathy has been a 4-H volunteer leader for 12 years.

She has been involved in a variety of wildlife, shooting sports and fisheries projects. When her county hosted the State Shooting Sports/Wildlife Invitational, she was responsible for exhibits and for the Wildlife Knowledge Bowl competition. She also has been involved in leading wildlife and fisheries workshops and training for other adult and junior 4-H leaders. She is active in her state's 4-H Sportfishing Program, is a certified wildlife program leader and serves as a leader, trainer and coach for the state 4-H Wildlife Habitat Invitational and Shooting Sports Programs.

Kathy plans to continue her work in 4-H in areas of natural resources management and would like to become a state trainer. Kathy says that she believes that the skills and leadership that youth learn and exhibit through participation in 4-H will benefit them throughout their life and she is committed to serving as a leader to help encourage and enrich their wildlife and natural resource education and understanding of conservation principles.

ALLAN PRIBNOW

Allan is a retiree from Port Wine, Wisconsin, in Bayfield County, along the shores of Lake Superior. He was a 4-H member during his youth and, about 12 years ago, after seeing a newspaper article, he volunteered to become a leader. After about eight years of teaching and coordinating Shooting Sports in central Wisconsin, Allan retired, moved north and more or less started over, instituting a 4-H Shooting Sports Program in his new home county.

Allan feels that the Shooting Sports Program is one of the greatest tools we have for teaching youth skills and values related to sportsmanship, conservation, ethics, physical and mental control and concentration. He has not limited his activities to Shooting Sports. He has become one of the most active proponents of the National 4-H Sportfishing Program and has seen it blossom under his leadership, as a mechanism to reach extended family: 4-Hers, parents, grandparents, relatives and friends.

Allan is currently deeply involved in a proposal to develop an Outdoors

Skills Center. He shows no signs of slowing down and, when the Outdoor Skills Center is up and running, he will find plenty of other things to do. He has received both state and national awards for his contributions as a conservation educator, but he emphasizes that the greatest reward is helping others gain an appreciation for wise stewardship and having them contribute what they have learned to the education of future generations.

Conclusion

We deeply appreciate the many contributions these six people have made of their time, expertise, commitment, and love to help 4-H youth learn about the wise stewardship of fish and wildlife resources. It has been a privilege to recognize their accomplishments in partnership with U. S. Department of Agriculture.

This partnership between our agencies, including recognizing these outstanding volunteers for the past 20 years, has shown how people with a common vision and commitment can help agencies forge partnerships that strengthen natural resource management and directly and indirectly contribute to improving the lives of people. We value this partnership with the Fish and Wildlife Service and we appreciate their continuing support for this program. We also appreciate the long-term support of the Wildlife Management Institute, the International Association of Fish and Wildlife Agencies, the Boone and Crockett Club and the National Rifle Association for their contributions to the Recognition Program and to these great leaders.

Session One.
Wildlife Harvest Regulations: Lesson Learned, Current Challenges and Prospects for the Future

Chair

BYRON K. WILLIAMS

U.S. Geological Survey

Reston, Virginia

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R. BEN PEYTON

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East Lansing

Perspectives on Regulation of the Sport Harvest of Wildlife

Byron K. Williams
U.S. Geological Survey
Reston, Virginia

The focus of this Special Session is regulation of wildlife harvests and, more specifically, regulation of sport harvests. A traditional issue in wildlife conservation, the sport harvest of wildlife continues to be an ongoing and active concern in the conservation community. In the United States, the responsibility for managing migratory wildlife is shared between the federal and state governments, whereas responsibility for non-migratory wildlife not otherwise threatened or endangered resides with the states. Over the years, rather elaborate mechanisms have been developed for the regulation of harvests, which include wildlife monitoring and assessment, public involvement and formal processes for promulgating, communicating and enforcing harvest regulations.

The biological framework for these efforts can be described in terms of

(1) the influence of regulations on harvest amounts and rates, and (2) the influence of harvest on biological processes such as survivorship and reproduction and, hence, on population dynamics (U.S. Department of the Interior 1988). According to this scenario, annual hunting regulations combine with population status, environmental conditions and hunter behaviors to influence the level of harvest from a population. The direct effect of harvest is to reduce population size, with additional impacts on survivorship and reproduction through density dependence and other mechanisms. Population responses to these effects in turn influence prospects for harvest opportunities in the future. An important management question is how to establish harvest regulations each year so as to meet social and biological goals, while providing for long-term conservation and future harvest opportunities.

Long-standing controversies continue to surround the regulation of harvests. For example, questions remain about the importance of regulations versus environmental and socio-economic factors in determining harvest levels. In particular, the relative influence of regulations, population status and weather during the hunting season continues to be an issue (Johnson and Williams 1999). In addition, there is uncertainty about the degree to which the effects of harvest are compensated either by changes in other sources of mortality (Anderson and Burnham 1975, Nichols et al. 1984), or by changes in reproduction/recruitment via density-dependent mechanisms (U.S. Department of the Interior 1988). As the regulation of harvests has become more elaborate, with a proliferation of species-specific regulations, special seasons and ever-increasing specificity as regards hunting gear, geographic location and hunting groups, serious questions have arisen about the ability of monitoring systems to recognize the impacts of regulatory changes. It appears that the scale of regulations is outstripping the scale of monitoring and assessment by which regulations can be evaluated and guided. These and other problems increase the potential for political intervention to undermine established regulatory structures and processes.

This session addresses a number of these issues and concerns about the regulation of wildlife harvests. The session is divided into two panels, one focusing on harvest regulations for species for which federal and state governments share responsibility, and one focusing on the harvest of species that are exclusively under the authority of the states.

The first panel addresses the harvest of waterfowl, an issue of great importance for both the federal government and the states. The U.S. Department of the Interior has statutory responsibility for migratory bird management under the Migratory Bird Treaty Act, including the management of harvests, conservation of migratory bird habitats and monitoring of bird population status. These management responsibilities are shared with the states and coordinated through the Flyway Management System (Blohm 1989).

The second panel addresses the management of wildlife harvests via state regulations, centering on the regulation of method of take in archery. Presentations in this panel focus on processes and institutional arrangements that define regulations-setting by the states, particularly in a context of political oversight and involvement by bodies representing elected representatives.

At issue is the promulgation of effective federal and state regulatory strategies in a political context, recognizing that wildlife populations are subject to many influences that cannot be controlled by management. Of predominant importance is uncontrolled (and often unrecognized) environmental variation, which influences biological processes and induces randomness in population dynamics. Another important factor, mentioned above, is a limited ability of regulatory decisions to influence harvest amounts and rates. No matter how extensive, monitoring programs inevitably provide managers only partial information about the status and distribution of harvested populations. Finally, management typically is constrained by a lack of understanding (or lack of agreement) about the structure of biological relationships linking harvest and population response. These factors, separately and in combination, limit a manager's ability to implement effective regulations pursuant to management goals (Williams et al. 1996).

We begin with a description of the process of regulating waterfowl harvests, under the rubric of adaptive harvest management (AHM). AHM grew out of a system of monitoring, assessment and regulatory decision-making mandated by the Migratory Bird Treaty Act. Operating within an institutional decision-making framework and utilizing large-scale waterfowl monitoring programs, it incorporates (1) an array of regulatory options that are available for the regulation of harvests; (2) objective functions that incorporate population status and harvest amounts, by means of which to evaluate and compare regulatory options; (3) population models representing an array of meaningful hypotheses about the biological impacts of harvest regulations; and (4) measures of reliability for these models, which are included in the objective function and used in selecting harvest regulations (Johnson et al. 1997). A difference between AHM and more traditional approaches is an explicit acknowledgement of alternative hypotheses about the effects on populations of regulations and other environmental factors. By iteratively identifying optimal regulatory choices with models expressing these hypotheses, and subsequently updating the model reliability measures each year, the AHM process eventually recognizes the most appropriate hypothesis and, thereby, yields the most appropriate regulatory strategy (Williams 1996).

Of the many advantages of an adaptive approach to harvest management (e.g., Williams 1997), perhaps the most important is a reduced ambiguity attendant to the explicit description of harvest objectives, biological assumptions and the other elements of AHM. On the other hand, the continued use of an adaptive approach is by no means assured, in part because of the rigor it imposes on managers as they struggle with increasing resource demands in an environment requiring common harvest goals and a stable, publicly accepted process.

More generically, the challenge facing managers of sport harvest is to retain a long-term institutional commitment to harvest management that is science based and objective driven, and thus able to continue delivering harvest opportunities while conserving wildlife populations for future generations. This challenge, and the management philosophy that underlies it, serves as a principle for the setting of harvest regulations and applies to the sport hunting of waterfowl, the regulation of archery hunting or, more generally, regulations-setting for any wildlife population under any authority, whether state or federal.

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Evolution of Harvest Management for North American Waterfowl: Selective Pressures and Preadaptations for Adaptive Harvest Management

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In 1995, the U.S. Fish and Wildlife Service introduced an adaptive approach to the establishment of hunting regulations for mid-continent mallard ducks. The use of this approach, known as adaptive harvest management (AHM), has continued for mid-continent mallards and is being considered for use with other mallard populations, as well as with other North American ducks and even geese. In this paper, I briefly discuss the history of waterfowl management in North America, focusing on events that appear to have been influential in producing changes in management approaches and that eventually led to the adoption of AHM. Throughout this historical review, I view duck harvest management as a system undergoing evolutionary change. From an evolutionary perspective, the reasons underlying these changes can be viewed as selective pressures. Some components of past management have been especially conducive to the adoption of AHM and can be viewed as preadptations facilitating the implementation of the approach.

Selective Pressures: Early History

When natural resources are viewed as infinite, there is little motivation to provide any sort of management. Prior to the mid-1800s, waterfowl were extremely abundant in North America, and there was no effort to regulate either the recreational or market hunting that occurred throughout the year (Phillips and Lincoln 1930, Day 1949). Declining populations in the late 1800s and early 1900s brought concern. These concerns can be viewed as the initial selective pressures for governmental intervention in the form of hunting regulations and habitat acquisition. The United States government was granted authority to establish hunting regulations, and the Migratory Bird Treaty Act of 1918 specified that hunting would be permitted only to the extent that it was compatible with protection and maintenance of populations (Day 1949, U.S. Fish and Wildlife Service 1988).

During the period from 1930 to 1950, North American waterfowl populations were frequently low. Perceived declines in abundance triggered the common sense response of restrictive hunting regulations (U.S. Fish and Wildlife Service 1988). During the subsequent 25 years (approximately 1951-1975), data collection programs initiated in previous decades were expanded and improved (Martin et al. 1979, Nichols 1991a). During this period, data from these monitoring programs were used to develop population models for the specific purpose of setting harvest regulations (Crissey 1957, Geis et al. 1969). These population models specified the response of duck populations to changes in hunting mortality. During years of dry conditions on the breeding grounds and low waterfowl abundance, restrictive hunting regulations were imposed and disagreements arose about the relative importance of duck population status versus the desires of segments of the hunting public. In addition, some stakeholders questioned the need for restrictions, arguing that population changes were largely governed by habitat and that restrictive hunting regulations contributed little to population recovery. However, these arguments were not accompanied by any compelling evidence, scientific or otherwise, leaving little reason to question the model-based predictions about duck population responses to harvest regulations. The 1960s and early 1970s were thus characterized by political pressure for change in approaches to harvest management. However, there was no scientific basis for questioning the harvest management models that were in use at the time. In fact, except for the various political disagreements, North American waterfowl management in the 1960s and 1970s was viewed as a good example of scientific management of animal populations (Nichols et al. 1995).

In summary, the realization that the waterfowl resource was finite, and that abundances were sometimes lower than desired, was the primary selective pressures underlying evolutionary changes in North American waterfowl harvest management during the first three-quarters of this century. The model-based management system that resulted was viewed as a good, and perhaps optimal, solution to the problem of harvest management (i.e., it was viewed as a "peak" in the adaptive landscape). During the 1960s and 1970s, selective pressures for changes in management originated in the political, but not the scientific, arena.

Selective Pressures: Recent History

Mallard Survival

In the late 1960s and early 1970s, D.R. Anderson conducted a series of analyses of banding and recovery data for mallards banded during the preseason period (July-September) throughout North America. These analyses resulted in the Mallard Report series published by the U.S. Fish and Wildlife Service. Mallard Report VI was based on new methods for estimating survival rates (Brownie et al. 1978), and contained new theory and new analyses conducted by Anderson and Burnham (1976) directed at the question of how annual survival rates of mallards are affected by changes in hunting regulations and hunting mortality rate. This report demonstrated that the negative linear relationship between hunting mortality rate and annual survival rate incorporated into the management models of the time (e.g., Geis et al. 1969) was a statistical artifact resulting from sampling covariances. New analyses directed at this same relationship using more appropriate statistical methods provided little evidence that historical increases in hunting mortality had produced declines in annual mallard survival rates (Anderson and Burnham 1976).

The publication of Anderson and Burnham (1976) was an extremely important event in the evolution of waterfowl harvest management, because it introduced the recognition of *structural uncertainty* into the management process. Prior to 1976, North American waterfowl managers recognized three forms of uncertainty that influenced harvest management: *environmental variation* (e.g., variation in wetland conditions strongly influenced mallard reproductive rates and, hence, abundance), *partial observability* (state variables, such as population size, and objective function variables, such as harvest, are not known but must be estimated), and *partial controllability* (control variables such as harvest rate cannot be imposed directly, but instead must be applied indirectly through the establishment of hunting regulations). Structural uncertainty refers to uncertainty about system response to management actions.

Prior to publication of Anderson and Burnham (1976), the models developed in the 1960s to predict waterfowl responses to changes in harvest rate were believed to be good approximations to reality. These models were similar to those used in much fisheries management in that hunting mortality acted in an additive manner (as an independent competing risk) to increase overall mortality. Compensatory population responses were thought to occur only through density-dependent reproductive rates. Anderson and Burnham (1976) developed explicit expressions for the additive and compensatory mortality models and presented some evidence in favor of the compensatory hypothesis and against the additive hypothesis that had formed the basis for previous waterfowl harvest management. Waterfowl biologists and managers were thus forced to consider structural uncertainty in the form of competing models for population responses to management actions. This structural uncertainty has been a strong selective pressure underlying the evolution of waterfowl harvest management during the past 25 years.

Stabilized Hunting Regulations, 1979-1985

The issue of structural uncertainty about the manner in which waterfowl populations respond to harvest mortality led to serious efforts by waterfowl biologists and biometricians to resolve this uncertainty through retrospective analyses of historical data. Following the publication of Anderson and Burnham (1976) there have been many such analyses, and results have been summarized periodically (Nichols et al. 1984, U.S. Fish and Wildlife Service 1988, Nichols 1991b, Nichols and Johnson 1996). The retrospective analyses conducted during the 1970s and 1980s suffered from a problem identified by Anderson and Burnham (1976) in their initial work. That problem concerns the manner in which historic harvest regulations were purposely set in a manner that tracked waterfowl abundance and habitat conditions. Basically, waterfowl hunting regulations have been relatively liberal during years characterized by high waterfowl abundance and good habitat conditions (large numbers of wetlands on the breeding grounds) and restrictive during years of low abundance and poor wetland habitat (Anderson and Burnham 1976, Nichols et al. 1984, Nichols et al. 1995). In response to the inferential problems caused by this historical covariation, various scientists and managers have recommended establishing hunting regulations on an experimental basis in a deliberate attempt to break this covariation and learn about population responses to hunting (e.g., Anderson and Burnham 1976, Nichols et al. 1984, Anderson et al. 1987, Nichols 1991b).

These recommendations for experimental harvest manipulations were judged to be socially and politically unacceptable and thus were never followed. However, waterfowl managers and scientists were still serious about trying to reduce structural uncertainty and learn more about population responses to harvest. A different way to break the covariation between hunting regulations, abundance and breeding ground habitat conditions is to stabilize hunting regulations at some predetermined level. Changes in population dynamics occurring during periods of stabilized regulations would have to be attributed to the environment and factors other than hunting regulations.

In 1979, the Canadian Wildlife Service and the prairie provinces of Alberta, Saskatchewan, and Manitoba initiated a program of stabilized hunting regulations, and the United States followed in all four flyways in 1980 (Brace et al. 1987, U.S. Fish and Wildlife Service 1988). Season lengths and bag limits were stabilized at 1979 levels through the hunting season of 1984-85. A number of large-scale waterfowl research studies were initiated on both the wintering and breeding grounds in order to take advantage of this period of static regulations and learn about the importance of environmental and other variation in duck population dynamics (McCabe 1987). Some of these studies were directed at questions about seasonal mortality, and possible density-dependence of such mortality, in an effort to investigate possible mechanisms that were hypothesized to underlie compensatory mortality processes (e.g., Blohm et al. 1987, Reinecke et al. 1987). Other studies included continental survey data from the period of stabilized regulations in new retrospective analyses (e.g., Caswell et al. 1987, Reynolds 1987, Trost 1987, Trost et al. 1987).

Although much was learned about waterfowl population dynamics during the period of stabilized regulations (summarized in McCabe 1987), the collective studies did not lead to resolution of the structural uncertainty surrounding the manner in which hunting mortality influences total annual survival of ducks (Trost 1987, Sparrowe and Patterson 1987, U.S. Fish and Wildlife Service 1988). Nevertheless, the stabilized duck hunting regulations program represented a milestone in waterfowl harvest management, in that this was the first large-scale attempt to manipulate hunting regulations with an objective of understanding the population-dynamic consequences of management actions.

Questioning the Appropriate Scale for Management, 1985-1990

Following the period of stabilized duck hunting regulations, the U.S. Fish and Wildlife Service prepared a Supplemental Environmental Impact Statement for the issuance of regulations permitting sport hunting of migratory birds (U.S. Fish and Wildlife Service 1988). In response to continued structural uncertainty about population responses to harvest, the document recommended "a form of risk-aversive conservatism in which relatively restrictive regulations would be implemented for populations at low levels" (U.S. Fish and Wildlife Service 1988:96). It was stated that this recommendation "seems reasonable, given our current understanding of the relevant processes." This conservative approach was adopted by key state and federal waterfowl managers (e.g., Babcock and Sparrowe 1989) and represented an important shift in the policy of waterfowl harvest management.

This conservatism was accompanied by questions about the appropriate scale for harvest management. Information needs underlying management include information on system state (e.g., abundance of the population of interest) and on system responses to management, and such needs are expensive of funds and effort. In summarizing key results of the studies conducted during the period of stabilized duck hunting regulations, Sparrowe and Patterson (1987:324) noted that "the direction of waterfowl management during the past two decades has drifted strongly toward species management and toward greater fine-tuning of harvest management to allow more utilization of the resource." They then argued that the scale of management should be consistent with understanding (e.g., of the responses of populations to management actions) and capability to manage. Sparrowe and Patterson (1987) also considered operational stabilization of hunting regulations for periods of several years (a consideration of temporal scale) as a means of reducing annual expenditures of effort on regulatory decisions, as well as to facilitate learning.

The issue of appropriate scale for management was revisited at a special session organized by R.D. Sparrowe and K.M. Babcock for the 54th North American Wildlife and Natural Resources Conference in 1989. One review of previous efforts to evaluate duck harvest management concluded that the benefits expected to result from efforts to "fine-tune" management frequently will not justify the increased cost of evaluation (Nichols and Johnson 1989). In the session summary, Babcock and Sparrowe (1989:598) included the following two recommendations in a list of challenges to the conventional wisdom of waterfowl harvest management:

- "In the long term, consideration should be given to accepting moderate duck hunting regulations in lieu of continuing costly efforts to precisely measure population levels, mortality and survival with the intent of adjusting seasons annually by a few days or by a duck or two in the bag.
- "Current regulation-setting schedules should be examined to determine if changes are practical. Serious consideration should be given to establishing duck hunting regulations on three-year cycles."

The period 1985 to 1990 thus was characterized by two substantive shifts in attitude about harvest waterfowl management. The first recommended a conservative, more restrictive approach as a reasonable response to structural uncertainty. The second suggested that frequently management scale was not consistent with available information or the ability to evaluate, and recommended a reduction in the fine-tuning of management actions. One of the primary selective pressures that led to these shifts in attitude was structural uncertainty about the responses of waterfowl populations to harvest.

Preparing for Adaptive Management, 1990-1995

Many stakeholders were not happy with the shifts in attitude that followed the period of stabilized hunting regulations. Most of these stakeholders did not dispute the existence of structural uncertainty but instead questioned the reasonableness of the conservative response to it. Members of the Office of Migratory Bird Management of the U.S. Fish and Wildlife Service considered various approaches to harvest management and were attracted by the suggestions about experimental and adaptive approaches that were designed to manage in a way that would simultaneously achieve current goals and reduce uncertainty, thus facilitating achievement of goals in the future. Such an approach had been recommended by various biologists and statisticians and was conceptually appealing, but it had not been seriously attempted by a management agency.

In 1992, an *ad hoc* group of waterfowl managers and biologists from federal and state agencies was formed for the purpose of discussing alternativeapproaches to waterfowl management. The general concepts underlying AHM were introduced, and group discussions were used to elaborate these concepts and tailor an adaptive approach to waterfowl harvest management. Participants became members of an interagency working group on AHM, and several meetings were held between 1992 and 1995. All of the components of AHM and virtually every aspect of its possible implementation were discussed at the meetings of this working group. These meetings led to the publication of a paper describing the AHM approach and outlining the manner in which it could be implemented for mid-continent mallard ducks (Johnson et al. 1993).

The 1994-95 waterfowl hunting season was an especially frustrating one for many waterfowl stakeholders, as political intervention resulted in different regulations than had been recommended via the usual Flyway Council system. This season and its accompanying frustrations emphasized the need for a more objective approach to the establishment of waterfowl hunting regulations. Thus, in 1995, the U.S. Fish and Wildlife Service agreed to begin implementation of an adaptive approach to mallard harvest management. This implementation occurred in the 1995-1996 hunting season, and mallard hunting regulations have been established following an adaptive approach for the past five hunting seasons. This experience, and the methods used in implementation, have been well-documented (e.g., see Nichols et al. 1995, Williams and Johnson 1995, Johnson et al. 1997).

In summary, the primary selective pressure that led to the assembly of an interagency working group on AHM was again structural uncertainty and the belief that it should be dealt with in an objective manner. However, political intervention and resultant dissatisfaction with waterfowl hunting regulations in 1994 was an important stimulus to the actual implementation of AHM in 1995. Thus, the implementation of AHM for North American mallards can be viewed as resulting from a combination of selective pressures that included politics and scientific uncertainty.

Preadaptations

Many aspects of past waterfowl management and research facilitated the development and adoption of the AHM approach and can be viewed as preadaptations to this process. The five components necessary for adaptive management are: (1) management options, (2) clear objectives, (3) a model set, (4) measures of model credibility, and (5) a monitoring program.

AHM appears to work best with a small number of fairly different management options. Under early waterfowl harvest management in North America, season lengths and bag limits were considered as continuous variables subject to annual adjustment. However, the period of stabilized hunting regulations (1979-1984), and the subsequent emphasis on relatively stable regulations, led to experience with packages of regulations that were viewed as discrete sets. In fact, the problem of partial controllability was dealt with by estimating the distributions of harvest rates associated with the liberal regulations set of 1979 to 1984, the moderate set of 1985 to 1987, and the restrictive set of 1988 to 1993. This shift in temporal scale that occurred during the 1980s and early 1990s, and the discrete regulations packages that accompanied the different periods of stable regulations, can be viewed as a preadaptation for the management options required for AHM.

The long history of waterfowl harvest management in North America, and especially the Flyway Council system established to develop management recommendations, can be viewed as a preadaptiation to the development of an objective function for AHM. Admittedly, objectives were frequently assumed and seldom clearly specified in historical waterfowl management. The North American Waterfowl Management Plan (NAWMP) focuses on habitat, rather than harvest, management (Environment Canada and U.S. Department of the Interior 1986). However, NAWMP does specify numerical objectives for North American waterfowl populations and their habitats. In any case, the history in North American waterfowl management of thinking about, and sometimes specifying, management objectives can be viewed as a preadaptation to the specification of an objective function required by formal AHM.

AHM requires a set of models that is used to predict system response to management actions, and North American waterfowl biologists and managers have a strong history of model use (reviewed by Williams and Nichols 1990). The models of Anderson and Burnham (1976) still are used to reflect the structural uncertainty about the influence of hunting mortality on total annual survival rate, although alternatives are being considered (Johnson et al. 1993). The competing models developed to reflect different degrees of density-dependence in mallard reproductive rate (Johnson et al. 1997) are derivatives of models considered by Crissey (1969), Geis et al. (1969), Anderson (1975) and Brown et al. (1976). In these models, either number of young or the young per adult ratio are predicted as a function of breeding population size of mid-continent mallards and number of ponds in prairie breeding areas. Thus, the strong history of model use represents another preadaptation to AHM.

Waterfowl biologists and managers have been accustomed to arguing the relative merits of different models but unaccustomed to translating such arguments into actual measures of credibility. However, the historical analyses on the effect of hunting on overall survival (Nichols et al. 1984, U.S. Fish and Wildlife Service 1988, Nichols 1991b), for example, provided a basis for computing likelihoods of the compensatory and additive models. These likelihoods were not used in 1995, as it was decided to assume the four models to be equally credible, *a priori*. However, historical evaluation of competing models can still be viewed as a preadaptation for considering and computing measures of model credibility.

Finally, the monitoring efforts for North American waterfowl have developed into the most comprehensive population monitoring program for any group of terrestrial animal species in the world. These programs yield annual estimates of the state variable of interest, population size, as well as of other quantities (e.g., annual survival rates, age ratios, harvest rates) that are useful in updating measures of model credibility and in refining other aspects of the models. Established monitoring thus constituted an extremely important preadaptation to the AHM process.

In addition to preadaptations for the five components of AHM, scientists involved with natural resource management began to consider use of the specialized optimal stochastic control methods needed in this process. In the implementation of AHM for mid-continent mallards (e.g., *see* Johnson et al. 1993, 1997; Nichols et al. 1995), each spring a set of hunting regulations must be selected for the following hunting season. That decision is based on the objective function, the state of the system (the number of mallards in the breeding population, the number of ponds in prairie breeding areas), the updated measures of model credibility, and the models themselves. The methods used to compute the optimal decision from the preceding information are fairly complex and unknown to many (most?) wildlife managers and scientists.

In 1975, D. R. Anderson published results of his Ph.D. thesis research dealing with application of optimal stochastic control methods to mallard harvest management. At a time when most wildlife biologists knew nothing about such methods, a U.S. Fish and Wildlife Service scientist interested in waterfowl management developed an understanding of these methods and then illustrated their potential using an example of waterfowl harvest management with competing models (Anderson 1975, 1985). Other scientists have become interested in applying these methods to problems in natural resource management (e.g., Clark 1976, Williams 1982, 1985, 1989, Walters 1986, Cohen 1987, Hilborn and Walters 1992), and some have focused specifically on waterfowl harvest management (Cohen 1986, Williams 1988, 1996). Algorithms and associated software for solving problems in optimal stochastic control have been developed with natural resource management in mind (e.g., Williams 1988, Lubow 1996). Experts in this methodology have participated at AHM working group meetings and have developed software specifically for the AHM program. This methodological expertise of scientists interested in waterfowl management was an important preadaptation to AHM and has been essential to the development of the program.

In summary, several aspects of past waterfowl management and research facilitated the development and adoption of the AHM approach and can be viewed as preadaptations to this process. With respect to the five components necessary to carry out AHM, the existence of an excellent monitoring program and a good set of competing models of system response were probably the two most important preadaptations useful in the establishment of AHM. Methodologically, the existence of scientists who were knowledgeable about methods of optimal stochastic control and who wanted to apply these methods to duck harvest management was extremely important to the development of the AHM process.

Conclusion

Many different selective pressures appear to have contributed to the evolution of waterfowl harvest management. Political differences and scientific uncertainty about the responses of duck populations to hunting were important to the recent adoption of the AHM process. From an evolutionary perspective, the selective pressures that led to the adoption of AHM are even more strong and compelling today than they were during the years of development of the AHM program. This historical review thus leads to the strong conclusion that the continuation and expansion (to other species, locations, and types of management actions) of adaptive management should be a primary focus of waterfowl management efforts during the next century.

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Adaptive Harvest Management: Has Anything Really Changed?

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This is no time to experiment with substitutes or to squabble about petty, unpopular and unenforceable shooting restrictions presumed to provide the remedy.
More Game Birds in America (1933)

The longer I study waterfowl problems, the more convinced I am of the seriousness of long open seasons. To conserve our wild ducks and geese, and perhaps to bring about increases in the numbers of a few species, the bag limits must be kept low, and open seasons must be short.
M.D. Pirnie (*in* Lumley 1936: Foreword)

Management of duck harvests has been among the more debated wildlife resource issues during the last 60 years. The controversy was particularly apparent during the 1980s as wetland habitat conditions and populations of ducks reached levels reminiscent of the 1930s. With severe restrictions in harvest opportunity, waterfowl managers were forced to confront long-standing harvest management issues. In 1988, a supplemental environmental impact statement (SEIS 88) on the sport hunting of migratory birds outlined a preferred alternative involving stabilized regulations and controlled use of "special" regulations (U.S. Department of Interior 1988). A desire for greater input into regulations by states, greater understanding of harvest impacts, increased hunting opportunity, and regulations simplicity were among the expectations of the flyways by the late 1980s (Babcock and Sparrowe 1989).

An adaptive management approach to develop duck regulations (Johnson et al. 1993) is an explicit, information-based process, which advances the credibility and integrity of duck harvest management. A Stabilized Regulations Working Group (later the Adaptive Harvest Management [AHM] Working Group) was established in 1992 to develop guidelines to provide (1) a sport harvest consistent with the long-term welfare of duck populations; (2) greater objectivity and predictability in promulgating regulations frameworks; and (3) greater ability to learn through experience. The AHM Working Group provided a shared technical forum comprised of state and federal waterfowl managers from all four flyways.

The need for an improved process for duck regulations again was confirmed in 1994 when moderate improvement in habitat and populations prompted a wide range of views about how regulations should be liberalized. Disagreements about resource status and proposed regulations (see *Federal Register* 59[163]: 43,684-43,698) ultimately resulted in a regulations approach involving options between season length and bag limits. As a result, an AHM Task Force, comprised of key state, federal and private individuals, was established by Mollie Beattie, the late U.S. Fish and Wildlife Service Director, to guide implementation of the AHM program already in development by the AHM Working Group.

Within a decade, North American duck populations and their habitats have undergone dramatic recoveries, and waterfowl regulations also have evolved. AHM has provided a technical framework within which the science of waterfowl harvest management has been advanced. The following evaluation of harvest management progress is in the context of expectations that have not changed (Babcock and Sparrowe 1989) and the AHM, which has changed the nature of the debate (Table 1).

Expectation: Regulations Based on Flyway or Subunit

The distribution of waterfowl, waterfowl hunters, harvest, hunting opportunity, wetland habitats, and the traditions and experience among hunters and waterfowl managers have never been equal within or among flyways (Figure 1). Thus, each state and flyway brings a unique and legitimate perspective to the regulations process. Concerns in the Atlantic and Pacific flyways about regulations tied to the midcontinent (Strange et al. 1989, Molini 1989) have been similar to the Central Flyway's concern about undue regulations influence by the Mississippi Flyway (Lewis 1989), but they are opposite the concerns of the Mississippi Flyway about sharing in harvest restrictions (Miller 1989). As a result, the dispute about "a fair allocation of these shared resources" (Lewis 1989) has not changed.

The ongoing disagreement involving regulations issues related to framework extensions in southern Mississippi Flyway states was still apparent during 1997 to 1999. Although the language of the technical process has changed during AHM development, the language of the philosophical debate largely has remained the same. Characterized as "totally unfair," "blatantly unfair," and "patently unfair," the frameworks debate has typified historic concerns about "the fair allocation of a shared resource and mechanisms used to achieve that allocation" (*Federal Register* 63[150]: 41,925-41,932).

So, if the debate remains, what has AHM done to resolve the concerns about waterfowl harvest management? AHM provides an objective, data-based approach to developing regulations recommendations by (1) explicitly defining a harvest management objective, (2) limiting the number and nature of regulations options, (3) developing models that predict response of populations to harvest and environmental conditions, and (4) specifically defining how data will be used to update measures of reliability of each population model (Johnson et al. 1993, Williams et al. 1996).

The explicit nature of AHM has changed the technical process of developing regulations recommendations; however, there is a need to clearly separate the issue of deciding on the annual optimum level of harvest from the debate about how the harvest will be shared (Johnson and Williams 1999). It is inappropriate to criticize AHM because harvest distribution is perceived to be unfair (D.R. Anderson, personal communication: 1993).

Table 1. Expectations for waterfowl harvest management (Babcock and Sparrowe 1989) and the roles of adaptive harvest management.

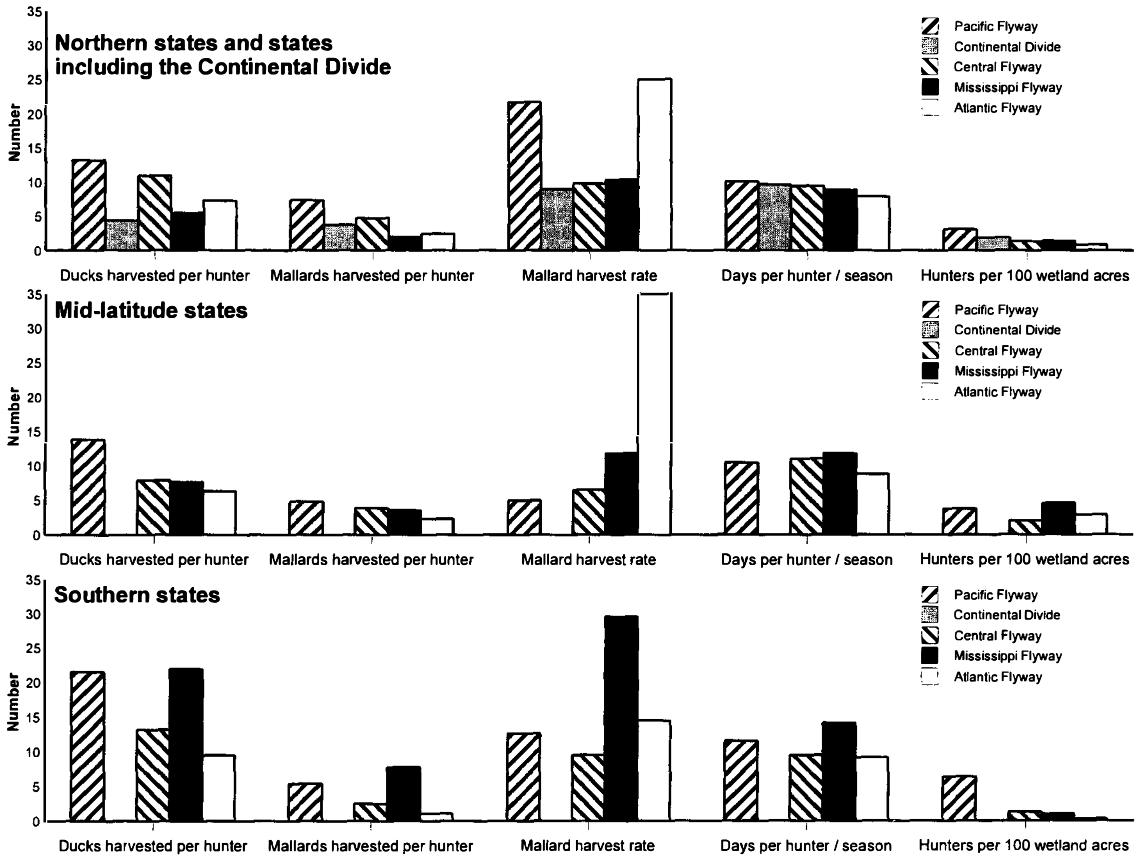
Harvest management expectations	Contributions from AHM--what has changed?	Challenges remaining--what hasn't changed?
Flyway or unit-specific regulations	Agreement on the distribution of harvest is not a role of AHM.	Debate continues regarding fair allocation of a shared resource and the mechanisms used to achieve that allocation.
Higher populations to provide greater hunting opportunity and harvest success	Objective: maximum long-term harvest consistent with the population goal for mallards; revised in 1995 to emphasize equally the value of harvest and the status of mallard breeding population.	Uncertainty remains about the relative role of harvest and environmental conditions on duck populations.
Maintain traditional harvest opportunities	Regulations packages developed in 1995 and revised in 1997 limited the number and nature of regulations options and were based on historic harvest distribution.	Agreement is needed on a consistent set of regulations options. Evaluate hunter desires and consider incorporation into AHM.
Greater understanding of harvest impacts on populations	Models incorporate hypotheses about the role of harvest and environmental conditions on duck populations and model predictions are compared (and weights updated) through ongoing monitoring programs.	Resolve reporting rates and improve recruitment and survival models.
Fully justified and easily understood regulations	A stable process for recommending an optimal strategy.	AHM provides for a stabilized process, not necessarily stabilized regulations, less regulations complexity is not likely, continued emphasis on communications is essential.
Greater input into harvest regulations	Shared development of AHM process through the AHM Working Group and implementation through existing processes.	Develop leadership to avoid "tinkering" with regulations and allow AHM to evolve.

Expectation: Higher Duck Populations to Provide Greater Hunting Opportunity and Harvest

Objectives for waterfowl harvest management historically were implied but never were explicitly stated. The struggle during early development of AHM to clearly define the harvest management objective for midcontinent mallards (*Anas platyrhynchos*) was evident in diverse views about the need to (1) maintain relevant duck populations above some minimum level; (2) maximize hunter numbers; (3) maximize bag limits; (4) maximize season length; (5) minimize regulatory changes; (6) minimize regulations complexity; (7) maintain regulation flexibility to achieve harvest objectives; (8) improve understanding of duck population dynamics; (9) gain knowledge about how regulations affect hunter activity; (10) understand how hunter activity affects harvest rates; (11) maximize equity in hunting opportunity; (12) improve public support and understanding of the regulations process; (13) avoid closed seasons; and (14) examine and realize the full potential for flyway-specific harvest regulations.

Some of these views were mutually exclusive, leading to an objective for maximum long-term harvest that is a product of numbers of hunters, their effort (days hunted) and their success (bag per day) and is in the context of North American Waterfowl Management Plan (NAWMP) goal for midcontinent mallards. Incorporation of the NAWMP goal reflects a desire to maintain numbers for harvest as well as "ecological and nonconsumptive purposes" (Johnson et al. 1997). This objective captures the overall intent of harvest management but does not reflect the regional differences in the weight placed on hunting opportunity, success and participation (Figure 1). Although an overall harvest objective is a clear improvement, the fundamental problem remains—how harvest and hunting opportunity are distributed.

Figure 1. Flyway and latitudinal differences in mean rates of harvest and hunting activity during 1996-98. Northern states include Washington,Oregon, and Idaho (Pacific Flyway), North Dakota and South Dakota (Central Flyway), Minnesota, Wisconsin, and Michigan (Mississippi Flyway), and Maine, Vermont, New Hampshire, Connecticut, Rhode Island, Massachusetts, and New York (Atlantic Flyway). Southern states included California, Arizona, Oklahoma, Texas, Alabama, Arkansas, Tennessee, Louisiana, Mississippi, North Carolina, South Carolina, Georgia, and Florida, respectively. The remaining states were termed "Mid-latitude," except for Montana, Wyoming, Colorado, and New Mexico which were combined into "Continental Divide" because wetland area estimates (used for hunters/100 acres) were available only by state (Dahl 1990). An index to mallard harvest rate was the ratio of the mid-winter index of mallards to the winter index plus the estimated mallard harvest (all estimates and indices from U.S. Fish and Wildlife Service survey data and archives, K. Gamble personal communication).


Northern states and states including the Continental Divide
Mid-latitude states
Southern states
Number
0
5
10
15
20
25
30
35
Pacific Flyway
Continental Divide
Central Flyway
Mississippi Flyway
Atlantic Flyway
Ducks harvested per hunter
Mallards harvested per hunter
Mallard harvest rate
Days per hunter / season
Hunters per 100 wetland acres

A tempting addition to the harvest management objective is to consider hunter satisfaction more completely. Views of hunters often have been cited as rationale for regulations changes. Motivations for hunting (defined by Enck et al. 1993), however, are not consistent among hunters. Ringelman (1997) surveyed duck hunters from 23 states and found differences in hunting activity, desire for specific regulations and motivations for hunting.

Certainly, *accurate* knowledge of attitudes and preferences will be important if a measure of hunter satisfaction is incorporated into objectives. Ringelman (1997) found discrepancies between waterfowl managers and hunters in how regulations were perceived to affect participation and satisfaction. In a 1999 survey of flyway council members, only 22.5 percent (n=40) reported that they relied greatly on information from surveys when regulations were developed (Table 2). Although few (30 percent; n=46) consistently conducted waterfowl hunter opinion surveys, nearly all (95 percent; n=41) indicated that they would participate if coordinated surveys of duck hunters were developed.

Although managers recognize the need for better information about hunter attitudes, it is not clear how measures of hunter satisfaction would explicitly be used to adjust regulations. Would adjusting regulations to meet changing hunter expectations be any different than "chasing populations and habitat conditions with regulations," which has been typical of the history of duck harvest management? Yet, it will be increasingly important to understand how hunter satisfaction, hunting activity and regulations are related if AHM is to provide complete insights into the effects of harvest management.

Expectation: Maintain Traditional Harvest Opportunities

The desire to provide maximum hunting opportunity in the face of changing population status and habitat conditions and the disagreement about harvest impacts on duck populations has been the basis for the historic conflict in duck

Table 2. Number of flyway council members that use various sources of information to develop waterfowl hunting regulations (based on a 1999 survey conducted at the four flyway council meetings).

Information source	Greatly (percentage)	Somewhat (percentage)	Not much (percentage)	Don't know
Attitude surveys (n = 40)	9 (22.5)	15 (37.5)	16 (40.0)	0
Telephone contacts (n = 40)	3 (7.5)	19 (47.5)	18 (45.0)	0
Letters/e-mail (n = 41)	5 (12.2)	26 (63.4)	10 (24.4)	0
Personal experience (n = 40)	10 (25.0)	22 (55.0)	8 (20.0)	0
Public meetings (n = 41)	14 (34.1)	20 (48.8)	7 (17.1)	0

harvest management. Duck harvest regulations became increasingly complex from the 1960s until the Stabilized Regulations Program from 1979 to 1984 (Brace et al. 1987) and more restrictive regulations were imposed through the 1980s. Nichols and Johnson (1989) reviewed the difficulty in evaluating the impact of regulations on duck populations and concluded that the benefits of fine-tuning harvest regulations may not be justified by increased cost of evaluation.

Traditional disagreements about the distribution of harvest and hunting opportunity were evident when AHM regulations packages were developed during 1995, revised in 1996-97, and adjusted to accommodate frameworks extensions in 1998 and 1999 (Office of Migratory Bird Management 1999). Again, the explicit approach under AHM resulted in discomfort among managers, largely because deliberations were based less on information and science and more on perception and historic differences in opinion. A recommendation (#5) from the joint flyway council meeting in 1996 (Mississippi Flyway Council 1996) offered general guidelines including (1) maintaining traditional flyway differences; (2) use of framework dates, season lengths and bag limits; (3) bag limits for species other than mallards, (4) the same number of regulatory alternatives used in all flyways; and (5) a maximum of five regulatory alternatives (excluding a closed season). Yet, concerns about the newly crafted regulations package included (1) inconsistencies among flyways in some regulations aspects (e.g. female mallard restrictions); (2) adjustments in harvest rates for declines in hunter numbers; (3) lack of accurate measurements of harvest rates until band reporting rates are known; (4) potentially high harvest rates on some mallard stocks (e.g., Great Lakes mallards) and unknown impacts on other duck species; and (5) communications challenges with more liberal options and relaxed mallard female regulations.

Specific current concerns about the future application of AHM involve three aspects related to regulations alternatives: (1) potentially closed seasons within the range of historic population levels and habitat conditions; (2) utility of a "very restrictive" regulations option; and (3) the nature of annual increments of changes in regulations (e.g., single-year change from a liberal to a restrictive season). The impact of suboptimal decisions on long-term AHM performance is unknown. For example, the consequences of employing restrictive seasons if "closed" seasons were the optimal choice, eliminating the "very restrictive" option, and limiting year-to-year regulations response to single increments need to be explored. A consensus on how to proceed in the event of various regulations scenarios (related to the above concerns) would be consistent with the explicit nature of AHM. Deciding now that a suboptimal regulations decision would be likely under certain conditions (e.g., continued open seasons with mallard populations that historically supported hunting) is preferable to waiting until we are faced with both deteriorating resource status and difficult decisions in conflict with the optimal AHM decision.

The limited number of regulations options, although reducing the temptation for annual "tinkering" with regulations, has been viewed as a constraint for species other than mallards. This was apparent in 1995 and 1996 when a debate about whether redhead (*Aythya americana*) bag limits should be one versus two in the Mississippi and Central flyways became a point of contention (*Federal Register* 60[166]: 44,463-44,476). This was a signal that species-specific harvest management would continue to be a regulations issue despite the progress for midcontinent mallards. This was further evident when interim northern pintail (*Anas acuta*) and scaup (*Aythya* spp.) harvest strategies were implemented in 1997 and proposed in 1999, respectively.

The U.S. Fish and Wildlife Service (Service), in their response to concerns about bag limits for redheads, proposed guidelines for long-term species-specific strategies rather than responses to short-term population changes (*Federal Register* 60[166]: 44,466) that included (1) assessment of how populations respond to harvest and environmental conditions, (2) criteria that prescribe how regulations should be changed, (3) range of regulations options that will be considered, and (4) considerations for determining the efficacy of the harvest strategy. Further, the Service recommended that proposals be developed in the context of AHM and that the AHM Working Group was the appropriate forum. This placed undue responsibility on both the AHM process and the Working Group and distracted technicians from the primary analyses for AHM.

Species-specific regulations should continue to be an issue for harvest management; however, an appropriate process for increasing emphasis has not been established. Despite gains in modeling for species and population segments, such as northern pintails (Scheaffer et al. 1999), eastern mallards (Johnson et al. 1999) and western mallards (Scheaffer and Malecki 1999), the propriety of a rigorous, adaptive approach to harvest management for most species should be questioned. Criteria that need to be considered to justify the expenditure of time and resources include population status, the availability of information for modeling and monitoring, "value" placed on a species by hunters, potential to impact harvest with regulations that primarily are established for mallards, the effect on regulation complexity, and indirect and direct costs (around $60,000 per year for model development).

The history of regulations has included a number of "creative" hunting regulations designed to increase opportunity for species or segments believed to be in relatively greater abundance or harvested at a relatively low rate (Ladd et al. 1989). When populations declined in the 1980s, some hunting opportunities (e.g., pre-sunrise shooting hours, special seasons, bonus bag limits and the point system) were eliminated (summarized in U.S. Department of Interior 1988).

The period of AHM has seen efforts to recover "lost" hunting opportunity while implementing a more credible regulations process. Undoubtedly, disagreements about regulations will remain, as evidenced by changes throughout the short history of AHM. Future debate about the regulations packages,be the result of

Expectation: Greater Understanding of Harvest Impacts on Populations

Uncertainty and disagreement about the impacts of harvest and habitat conditions on duck populations always has influenced duck harvest management decisions. Extensive survey efforts to determine population status, rates of mortality and survival, harvest and harvest rates, and habitat condition have continually been improved during the last half-century (Smith et al. 1989). Adaptive Harvest Management, defined as "managing in the face of uncertainty, with a focus on its reduction" (Williams and Johnson 1995), provides a formal framework within which objectives and uncertainties are explicitly addressed, and information is used to revise management approaches.

Modeling relationships among habitat conditions, reproduction, harvest, and population status as well as predictions about the influence of harvest and habitat on populations (Williams et al. 1996) was a prerequisite to AHM. As a result waterfowl managers and policy makers now share the same set of evolving models about the mallard life cycle and hypotheses about harvest and habitat influences. Questions remain about whether all essential environmental variables that affect mallard production or survival are included in AHM models (e.g. upland nesting conditions, wintering habitat, etc); however, AHM has provided a focus for improving the information needed to advance waterfowl harvest manage ment.

AHM provides a opportunity to improve monitoring and offer additional hypotheses about harvest or environmental impacts. Progress on key issues is apparent in investigations into recruitment and survival and efforts to improve estimates of harvest rates (Office of Migratory Bird Management 1999). Although disagreements remain about population dynamics and further improvements in monitoring will be required, specific needs are more apparent under AHM.

Expectation: Greater Input into Harvest Regulations

Establishment of the councils has resulted in better understanding of the problems involved in making the regulations. Council representatives *are now able to study and evaluate the same information available to the Service in deciding whether liberalizations or restrictions are in order. With this knowledge at their disposal, it is the obligation of each council to counteract unwise local pressures by presenting a united front in behalf of sound flyway management. It is the responsibility of individual states to squelch unsound demands and local pressures at home so that council sessions on regulations will not be cluttered with considerations which are not in the best interest of the flyway as a whole. Conversely, it is the responsibility of the Service to give full consideration to council recommendations. However, the final decisions regarding the waterfowl regulations have been placed by law in the hands of the Service.*

The Flyway Council System, established a half-century ago, ensured the collective input of flyway states into migratory bird management (Jahn and Kabat 1984, Wagner 1995). The waterfowl harvest issues facing managers, however, are essentially unchanged in the 1990s.

Mississippi Flyway Council (1958)

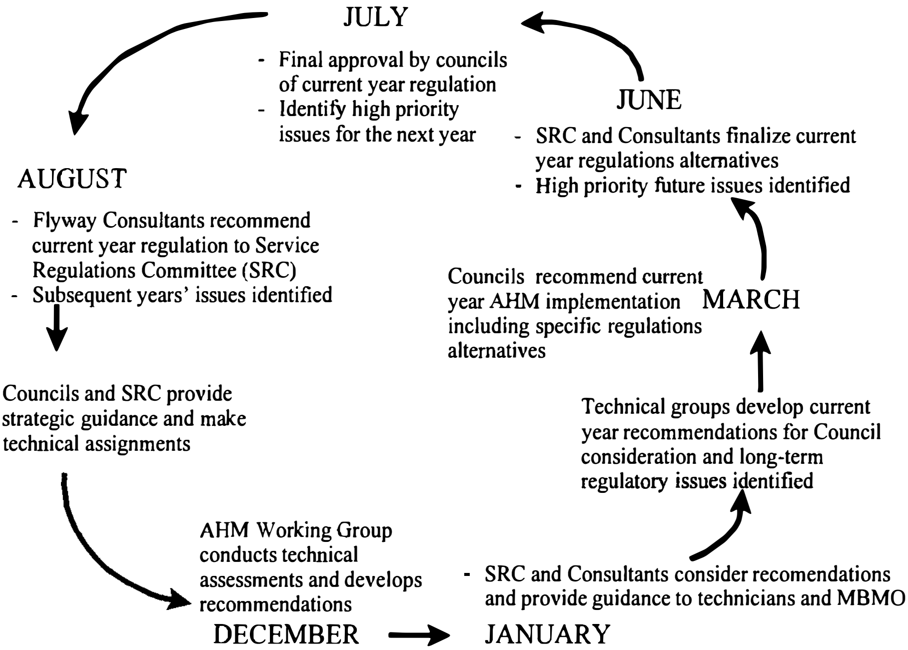
Little has changed in the administrative process of regulations development. The cycle of information gathering, state and flyway input, and federal frameworks recommendations have remained essentially unchanged for more than 20 years. Based on a recommendation (#4) from the joint flyway council meeting in 1996 (Mississippi Flyway Council 1996), the primary change in the process has involved early consideration (usually May) of the possible regulations alternatives for the current year (Figure 2). Knowledge of the possible regulations recommendations and the method of derivingthe optimal harvest (Lubow 1995, Johnson 1997) provides a common basis for earlier and more explicit regulation development.

Expectation: Fully Justified and Easily Understood Regulations

Regulation simplicity was a theme when hunting regulations for migratory birds were reviewed (U.S. Department of Interior 1988). Although not completely consistent with the intent of SEIS 88 for stabilized regulations, AHM has provided for more consistent expectations. Rather than stabilized regulations, AHM provides a stabilized process, and instead of more simple regulations, AHM at least provides fewer choices at an earlier time in the process.

The information-based nature of AHM ensures that harvest management is technically sound (fully justified), yet, it is not necessarily easily understood. AHM is attractive at an intuitive level because of the requirement for explicit

Figure 2. Annual cycle of flyway input into duck harvest regulations under Adaptive Harvest Management based on Joint Flyway Recommendation No. 4, Kansas City, Missouri, July 1996.



objectives, limited regulations options and methods for how information will be used to update management strategies. The rigorous nature of optimization, system modeling, model updates, and information feedback, however, is not intuitive to most managers and policy makers. Confidence in the technical recommendations will only evolve as innovative approaches are applied and incremental improvement in harvest management occurs. The process of AHM should be an invitation for critical involvement, not a target for criticism.

Understanding harvest management requires knowledge of the process and the fundamental biology involved. Thus, communicating AHM has become an essential part of recent harvest management efforts. Providing information about the process has required learning and understanding by managers and policy makers before concepts and details can be provided to the outdoor media and hunters. Recognizing this need, a communications committee was developed early in AHM evolution, and professional support was incorporated in 1995.

The AHM process, however, has developed during a period of improving habitat conditions and increasing numbers of ducks. Implementation of AHM almost has been "too easy" because there has been little bad news during this period of improved resource status. Thus, expectations for greater hunting opportunity also are linked to the timing of AHM. Most hunters likely have been aware only of the increase in hunting opportunity and reports of more ducks. Despite efforts to inform hunters about AHM, few are aware that the regulations recommendation process has changed. AHM will not likely be an issue with hunters until a counter-intuitive regulations recommendation occurs (e.g. maintaining a liberal season in the face of declining numbers). Our challenge is to inform waterfowl managers, policy makers, and hunters about the nature of population and habitat fluctuation so that the inevitable decline that is characteristic of ducks and wetlands is not perceived to be specifically due to AHM or to harvest regulations in general.

Conclusions

The complete prohibition of the use of live decoys has not generally met with favor in this section of the State and cannot within itself be considered a conservation regulation, but is in reality an ethical definition.
W. J. Tucker (*in* U.S. Government Printing Office 1937)

AHM has provided a forum for addressing the technical advancement of harvest management; however, lack of resolution of key "ethical definitions" will continue to characterize the ongoing controversy over regulations. Even if we discover exactly what impact harvest and habitat conditions have on duck populations, develop perfect knowledge of the impacts of regulations on harvest, understand the dynamics of hunter preferences, and measure all of these without error, disagreement about the nature of regulations likely will remain.

AHM can be a product of efforts to improve the science and apply the result. Yet, despite scientific precision and optimum decisions, without philosophical agreement on the goals of harvest management (and the leadership to maintain it), AHM may become little more than an intriguing technical exercise. Should we attempt to account for the vagaries of weather and habitat conditions on duck harvest distribution through regulations? The bottom line is that waterfowl harvest distribution is not equal and not fair. Ducks and duck habitat, weather, and hunters are not equally distributed. It is important to determine how much we should try to tailor regulations to create a perception of equity and fairness and what the possible measure would be. These will largely be value judgements, not decisions based on AHM models. Unless explicit decisions are made about the distribution of harvest and harvest management, decisions made about regulations will, by default, determine not only the overall harvest but *where* increases and reductions will occur. In this regard, the philosophical discussions about harvest distribution cannot be conducted in a U.S. vacuum—early incorporation of Canadian and Mexican views will be essential.

What will harvest management and perhaps AHM look like in 10 years? This will depend on (1) how we handle the next drought, (2) leadership in staying the course of AHM, (3) efforts by technicians and administrators to educate themselves about AHM, (4) resolution to the debate about how harvests are distributed, and (5) consciously separating the allocation debate from the technical process of developing an optimal harvest strategy.

Waterfowl managers and policy makers have been concerned that emphasis on hunting regulations has distracted the conservation community from more important habitat protection and restoration programs (Babcock and Sparrowe 1989). In this regard, AHM provides a model for evaluation of other management challenges. Coupling adaptive management processes for harvest with decisions about habitat management is the next logical step in information-based management of migratory bird resources.

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Adaptive Regulation of Waterfowl Harvests: Lessons Learned and Prospects for the Future

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Waterfowl managers in North America have been relentless in their pursuit of biological understanding, driven by a conviction that "science" eventually will provide the certitude necessary for effective management policies. Today, the system of waterfowl management in North America is unparalleled among conservation programs in terms of scope, complexity and cost (Hawkins et al. 1984). The record of accomplishment has been impressive, especially when compared with the more somber accounts of resource exploitation and collapse that tend to characterize much of the history of natural resource development (Ludwig et al. 1993). For all of the success, however, great uncertainty persists about the impacts of harvest and other relevant factors on the biological and social systems of interest. This lack of understanding continues to provoke controversy in the setting of waterfowl hunting regulations, particularly in the U.S. where most of the North American waterfowl harvest occurs.

In response to a rising tide of regulatory frustration, the U.S. Fish and Wildlife Service adopted a formal framework for the adaptive management of waterfowl hunting regulations in 1995. Adaptive harvest management (AHM) is intended to provide effective, or at least more objective, decisions in the face of uncertain regulatory outcomes, and a systematic approach for reducing those uncertainties. Some managers have characterized AHM as revolutionary, while others view it simply as a logical evolution of the previous management approach. After several years of implementation, comprehension and expectations of AHM vary greatly, despite a substantial investment in communication with both internal and external audiences.

In retrospect, AHM was accepted rather readily by waterfowl managers, perhaps reflecting the belief that difficulties in harvest regulation are principally a function of incomplete biological information. After all, this narrow focus has been the driving force throughout much of the waterfowl management history, and the expectation that science can resolve management problems has become rather pervasive. As a result, AHM occasionally is perceived as a panacea, with expectations that belie the complexity of both biological and sociopolitical systems. To the surprise of some, AHM has sometimes increased the contentiousness in decision making, while (at least so far) failing to reduce key uncertainties regarding regulatory impacts.

The failure of AHM to meet some managers' expectations may be in part because the process is challenging the traditional belief system that provides context for those expectations (Gunderson et al. 1995). Because of the explicit and formal nature of the AHM process, managers are being forced to question long-held beliefs about their ability to understand and influence the managed system, and about the potential of biological science to engender policy consensus. We characterize these traditional beliefs as myths of control, learning and goal setting.

Myths of control include the belief that there are tight linkages between hunting regulations, hunter behavior, harvest, and waterfowl population response. As we shall explain, managers' ability to control harvest and population size through the manipulation of hunting regulations is limited, especially when compared with the influence of environmental factors beyond the control of managers. A related myth involves the misconception that harvest strategies must or should account for all sources of variability in waterfowl demographics. The incredible proliferation of species and population-specific hunting regulations that occurred during the 1970s and 1980s is testament to this belief (U.S. Fish and Wildlife Service 1988). Perhaps this history is not surprising because most waterfowl managers were trained foremost in biology, where the search for demographic variation and its causes is the foundation of modern biological theory. In natural resource management, however, there is a pressing need to consider not only the benefits, but the direct and indirect costs of managing at progressively finer spatial, temporal and organizational scales.

Myths of learning include the belief that strong inference is possible in the absence of experimental controls, replication or randomization. There are severe practical constraints to using rigorous study designs for understanding migratory bird ecology (Nichols and Johnson 1989), and those constraints extend to the ability of AHM to elucidate the influence of harvest and other environmental factors on waterfowl abundance. Another myth of learning involves the unquestioned assumption that systems of interest are stable enough to permit learning. Ecological systems are constantly in flux, and there are serious questions about our collective ability to learn rapidly enough for the knowledge to be applicable to new or unexpected system behaviors.

Perhaps most problematic for the AHM process have been the myths of goal setting, which include the belief that broad, qualitative statements about desirable management outcomes are sufficient to define a unique management strategy. For example, there are many management strategies that could meet the basic goal of sustainable harvests, yet those strategies could all differ in ways that might dramatically affect how they are perceived and accepted by various stakeholders. A key difficulty in defining unambiguous management objectives in AHM continues to be uncertainty and disagreement about how harvest regulations affect behavior and satisfaction of waterfowl hunters.

Despite these difficulties, however, AHM remains one of the few large-scale, successful efforts to apply the principals of adaptive resource management. Thus, our goal is to examine critically what has been learned from the process since its implementation in 1995. We focus principally on the functional elements of the process, and the technical difficulties inherent in making informed management decisions for complex natural resource systems. However, much of what has been learned has more to do with the nature and functioning of institutions than with biology and the impact of regulations, and so we discuss those social aspects as well. We first briefly describe the AHM process to provide a framework for organizing and describing important lessons for the future of this effort. We conclude with comments about the success of AHM and the difficult challenges that remain.

The AHM Process

AHM is framed in terms of sequential decision making under uncertainty, or more formally in terms of a stochastic control process (Puterman 1994). In this process, the manager periodically observes the state of the system (e.g., population size and relevant environmental features) and takes some management action (i.e., hunting regulations). Based on this action, the manager receives immediate benefits (e.g., harvest) and incurs costs that are relevant to the stated objectives of management. The resource system subsequently evolves to a new state, with the change influenced by the management action and other uncontrolled factors. The manager then observes the new system state and makes a new decision. The goal of management is to make a sequence of such decisions, each based on information about current system status, so as to maximize net benefits over an extended time frame. A prescription of optimal management actions for each state of the system at each time constitutes a management strategy (or policy). These strategies can account explicitly for several sources of management uncertainty, including uncontrolled environmental variation, imperfect control over management effects and incomplete knowledge of system dynamics (Johnson et al. 1997).

There are three fundamental components of AHM (or of any decision-making process): (1) objectives that describe the preferred outcome of decision making and provide the metrics by which alternative decisions can be evaluated; (2) a set of alternative actions, which in this case are represented by different sets of hunting regulations; and (3) models that predict the consequences or outcomes of the alternative actions, in terms relevant to the stated management objectives.

A key feature of the AHM process is an explicit accounting for uncertainty about the impacts of regulations and uncontrolled environmental factors on waterfowl demographics. This uncertainty is expressed by a set of alternative system models, with each model empirically weighted in proportion to its predictive ability. The optimal regulatory decision in a given year is conditioned on both the system's state and the weights assigned to the alternative system models. Operational monitoring programs provide the basis for current regulatory decisions, as well as the means to compare predicted and observed management outcomes. Thus, AHM involves a three-step process: (1) each year, an optimal regulatory action is identified based on system state (i.e., population size and relevant environmental conditions) and on the weights associated with the alternative models of system dynamics; (2) conditioned on the optimal regulatory action, model-specific predictions for the subsequent year's population size are determined; and (3) when monitoring data from the subsequent year are available, model weights are updated to reflect the relative ability of each alternative model to predict the change in population size that actually occurred.

This process eventually will identify the model that most reliably predicts the population dynamics as a function of regulatory actions and other environmental factors. The current AHM approach is passively adaptive, in the sense that learning is an unplanned by-product of the regulatory process (Johnson et al. 1997). Actively adaptive strategies, in which there is a higher premium on learning, are currently under investigation.

Predicting Management Outcomes

Quantifiable predictions, which provide the basis for regulatory decisions and for future learning, depend on the availability of models describing system behaviors. In the case of AHM, these models must specify the differential effect of various hunting regulations, as well as uncontrolled environmental factors, on harvests and subsequent population size. Key system uncertainties are expressed by a set of alternative models, which represent competing hypotheses of system dynamics. Key considerations in this modeling process involve the breadth of system features, and the depth of the analysis to be considered. There are no manifest boundaries for defining natural systems or the limits of management responsibility and influence (Walters 1986, Levin 1992), therefore, the range and scale of system features to be considered must be guided closely by management goals and objectives. Moreover, modeling necessarily involves a process of synthesis, in which the fine-level detail of biological, physical and social systems must be abstracted to predict relevant behaviors with a minimum of model complexity.

The modeling of waterfowl population dynamics has a long and rich history (Williams and Nichols 1990), but useful models for harvest management purposes remain somewhat illusive. Some of the limitations in model availability and their utility have been self-imposed. For example, managers have been preoccupied with the effects of duck harvest on annual survival for almost 50 years, in spite of the fact that changes in duck population size may be more sensitive to variation in reproductive success than in survivorship (Martin et al. 1979). Moreover, the investigation of harvest effects on survivorship has been dominated by a focus on statistical correlations, at the expense of mechanistic models of the mortality process (Johnson et al. 1993). In this respect, there has been too little attention on the nature of density-dependence in mortality and reproductive processes in waterfowl, even though density-dependence provides the theoretical foundation for sustainable harvesting (Hilborn et al. 1995). In cases where AHM has stimulated these investigations, researchers have been stymied by questions concerning the most likely environmental limiting factors or by a paucity of demographic and environmental data at the necessary spatial and temporal scales. Clearly, the construction of useful models for harvest management depends on asking the right questions, and on the availability of data to stimulate the formation of useful hypotheses.

Another concern with the development of AHM models involves multiple sources of variation in waterfowl demographics (e.g., differences among species in rates of natural mortality) and the degree to which harvest strategies can or should account for those sources of variation. All ecological systems exhibit variability on a broad range of temporal, spatial and organizational scales, ultimately as a function of how individual animals respond to their environment (Levin 1992). The manner in which individuals are aggregated (e.g., by spatially segregated populations of conspecifics) for management purposes is an arbitrary decision, but one that can strongly influence both the benefits and costs of management. Management approaches that account for important sources of ecological variation are expected to yield the highest benefits, but also are characterized by relatively high monitoring and assessment costs (Babcock and Sparrowe 1989, Sparrowe 1990). There also may be social costs, as regulatory complexity increases to account for differences in the capability of various stocks to provide sustainable harvests. Determining the optimal level of aggregation for harvest management depends critically on the availability of explicit performance criteria (i.e., costs and benefits), and on understanding patterns of ecological variation. Description of these ecological patterns, in turn, depends on sufficient data to investigate potential sources of variation and to suggest underlying causal mechanisms.

Although the history of waterfowl management has been characterized by efforts to account for increasingly more sources of variation in waterfowl demographics, we believe there is reason to question the efficacy of this approach (Sparrowe and Patterson 1987, Johnson and Williams 1999). As the spatial, temporal and organizational scales at which harvest management is delivered become progressively smaller, we expect the marginal gain in management benefit to shrink (i.e., there is a point of diminishing return). At the same time, we believe management costs would continue to increase at a constant or even accelerating rate. Therefore, beyond some point, net benefit will decrease and may eventually become negative. Moreover, it seems that the limited resources typically available for waterfowl monitoring and assessment will constrain waterfowl managers to a fairly coarse-grained approach to hunting regulations. At least this should be the case if managers are committed to ensuring that the resolution of harvest management is consistent with the monitoring and assessment programs designed to support that management. It remains to be seen what level of resolution ultimately will be most appropriate in the AHM process, but we are increasingly concerned about what we see as unrealistic expectations for accommodating small-scale variation in waterfowl population dynamics.

Finally, the productivity of the modeling enterprise has been limited by a lack of attention to the social components of the harvest-management process. After all, managers do not control harvests directly, but rather must rely on the manipulation of hunting regulations. It seems obvious that understanding the relationship between hunting regulations and harvests is critical to sound harvest management, yet little is understood about how regulations and other factors affect hunter activity and success. Unfortunately, past experience is of limited utility. In most cases, the complexity of historic hunting regulations, combined with inadequate replication and experimental controls, has prevented managers from drawing strong inference about the relationship between regulations and harvests (Nichols and Johnson 1989). Managers know even less about how human demographics and economic factors affect waterfowl hunting activity. There have been profound long-term changes in the number of waterfowl hunters in the United States that cannot be explained by changes in regulations. Clearly, reliable harvest predictions depend in part on a better understanding of factors other than hunting regulations that influence waterfowl hunter activity and success.

Regulatory Controls

In AHM, regulatory controls have direct and indirect effects, and both are important to effective harvest management (Williams and Johnson 1995). Direct effects are manifested by the size of the harvest and the size of the waterfowl population (during at least part of the annual cycle). Regulations also have indirect effects by influencing the understanding of how populations respond to harvest. The design of regulatory alternatives, therefore, is not a trivial task, and involves several key considerations. First, the number of regulatory alternatives must be small to facilitate their assessment, although the set of alternatives can be expanded or limited as the need and desirability to do so is recognized. Second, the alternatives should vary enough so that differences in resulting harvest levels and impacts on population dynamics can be detected by extant monitoring programs. Finally, the needs of law enforcement and the desires and abilities of hunters should be considered in the formulation of regulatory alternatives.

Throughout the process of defining regulatory alternatives, managers must be mindful that the link between hunting regulations and resulting harvest rates is imperfect, and that the associated uncertainty in the relationship between regulations and harvest has important consequences for the AHM process. Even repeated experience with particular regulatory alternatives has failed to eliminate the high degree of uncertainty regarding the extent to which realized harvest rates are commensurate with expectations. Variation in weather and habitat conditions, timing of migration, hunter success, and countless other uncontrolled factors result in regulation-specific harvest rates that can vary by as much as ±50 percent of the mean (Johnson et al. 1997). Additional uncertainty is introduced when there is little or no prior experience with particular regulatory alternatives, such as some of those in use since 1997. Moreover, most empirical assessments have raised doubts about managers' capability to manipulate harvest pressure independently on multiple waterfowl stocks using conventional regulatory tools (Hochbaum and Walters 1984, Rexstad and Anderson 1988, Rexstad et al. 1991, Johnson and Moore 1995). The implications of these sources of uncertainty can be profound. Generally, less precision in the prediction of harvest rates leads to more conservative and more "knife-edge" harvest strategies. We characterize strategies as "knife-edge" when only small changes in system state (e.g., population size) are required to precipitate very large changes in the optimal regulatory choice. Conservative harvest strategies, with frequent annual changes in hunting regulations, are not likely to win favor among waterfowl hunters. It is not yet clear, however, that the waterfowl management community is prepared to acknowledge the inherent limitations in the ability to control and predict harvests, and to develop regulatory alternatives that help avoid the most undesirable consequences of those limits.

Ultimately, the design of regulatory alternatives involves subjective decisions. The AHM process cannot define an acceptable set of regulatory alternatives any more than it can define a useful set of population models. In practice, the design of regulatory alternatives for AHM has been heavily influenced by tradition, where the historic motivations and rationale for regulatory choices often are unknown or outdated. Therefore, there is a strong temptation among managers to promote non-traditional regulatory alternatives that influence the amount and distribution of hunting opportunity in ways that currently are deemed desirable. And there's the rub — the design of regulatory alternatives inherently involves value judgements, for which empirical data regarding harvest and population impacts are of limited utility (other than to constrain regulatory alternatives within biological and legal limits). In the end, managers from various parts of the country must understand how hunter satisfaction is influenced by the nature of regulatory alternatives and seek solutions that meet the needs of diverse interests.

Management Objectives

Natural resource management is a process of using biological information to predict the outcomes of alternative management actions, and then using sociological information to assign value to those outcomes (Lee 1993). AHM can produce optimal regulatory decisions (i.e., those with the highest expected value) in the face of uncertainty or disagreement about the outcomes of harvest management, but, if and only if, there is agreement about management goals and objectives. The basic objective of the AHM process since 1995 has been to maximize long-term cumulative waterfowl harvest, recognizing of course that long-term population viability is essential to attaining that objective. Against the backdrop of this basic objective, constraints are used to reflect social, economic, administrative, political, ecological, or other considerations. Constraints limit achievement of the harvest objective by restricting allowable options and, thus, tend to reduce overall harvest opportunity.

Perhaps not surprisingly, the magnitude of the annual waterfowl harvest may not be the most appropriate metric for the objective of the AHM process. Most waterfowl managers seem more interested in maximizing hunter satisfaction, recognizing that this is affected only in part by harvesting success. This view is supported by recent human-dimensions studies that indicate hunter participation and satisfaction are not increased substantially by regulations that provide for the maximum allowable harvest (Enck et al. 1993, Ringelman 1997).

Of concern, however, is evidence that managers continue to overestimate the importance of achievement-oriented factors in setting hunting regulations, ignoring evidence that waterfowl hunters are motivated to a large extent by the social and aesthetic aspects of the hunting experience (Ringelman 1997).

As early as 1993, there were discussions among those of us involved in AHM about framing objectives in terms that relate to hunter satisfaction rather than harvest (Johnson et al. 1993). We continue to see no theoretical problems in pursuing an objective defined in these terms, but clearly there are major challenges in application. In particular, what is the most appropriate metric of hunter satisfaction? How is it related to regulations and to attributes of the biological system (e.g., harvest and population size)? And what is the mechanism by which it would be monitored? The management community currently is ill-equipped to answer these questions. Certainly, a first step must involve a more systematic acquisition of information on hunter satisfaction, and how it is influenced by hunting regulations. In our experience, however, there seems to be a good bit of institutional resistance to human-dimension studies, perhaps due to privacy concerns, costs and a general feeling of discomfort among wildlife managers who naturally would rather focus on biological systems. We also recognize that human-dimension information could make management even more difficult, by exposing the extent of demographic and geographic variation in hunter's opinions. We cannot help but believe, however, that empirical data about that which motivates waterfowl hunters will be useful for improving waterfowl management in a variety of ways, some of which may not be directly related to the AHM process.

Whether the basic currency of management performance is expressed in terms of harvest or hunter satisfaction, constraints on the regulatory process will continue to be an important aspect of AHM. As we've discussed, current harvesting strategies and their associated performance are constrained by the inherent uncertainty associated with regulatory outcomes, but also by limitations purposely imposed by managers. An example of the latter is the population goal for midcontinent mallards from the North American Waterfowl Management Plan. Under conditions of poor population status and/or poor reproductive potential, the value of mallard harvest is devalued to help encourage population growth (Johnson et al. 1997). This constraint results in a regulatory strategy that is considerably more conservative than it would be in the absence of this constraint.

Other constraints are less obvious, particularly those involving the set of regulatory alternatives. For example, recent mallard population levels probably can sustain greater harvest pressure than that achieved even under the most liberal regulatory alternative currently available. Another example involves the constraining effect of regulatory alternatives on the frequency of regulatory changes. Frequent regulatory changes typically are deemed undesirable, and this can be addressed in part by specifying regulatory alternatives that produce large differences in expected harvests. However, to date there has been little effort within the AHM process to explore the relationship between regulatory alternatives and the expected frequency and magnitude of annual changes in regulations.

A difficult issue in the setting of harvest-management objectives involves the desired distribution or allocation of hunting opportunity among various parts of the country. In fact, a well-known scientist remarked in 1993 that failure to deal effectively with the issue of harvest allocation ultimately could lead to the "death" of AHM. For most of the history of AHM, however, there has been little attempt to address the issue in either an explicit or formal way. Recently, certain changes in the set of regulatory alternatives, as well as a growing awareness of long-term changes in harvest distribution, have elevated the issue to the forefront of management problems. The matter of "dividing up the pie" has become increasingly controversial, and now it threatens to undo much of the progress that has been made since 1995. Unfortunately, the lack of an effective process or protocol for organizing debate, as well as a paucity of information on hunter satisfaction, continue to be formidable obstacles to resolving the issue. As a first step, the management community must attempt to agree on criteria that characterize "fairness" in harvest distribution (Brams and Taylor 1996), so that appropriate computing procedures can be developed for the AHM process. In the end, however, managers must recognize that the distribution of hunting opportunity and associated harvests are influenced heavily by uncontrolled variation in habitat and weather conditions. Therefore, in spite of what managers do with regulations, the notion that "someone else, somewhere else is getting all the ducks" may remain a common perception among waterfowlers.

Learning

The ability to gain knowledge of population dynamics through the manipulation of hunting regulations is well known. In fact, waterfowl researchers often have advocated experimenting with regulations to help resolve uncertainty about the effect of harvest on annual survivorship (e.g., Anderson et al. 1987). Generally, managers have resisted such "probing" (Walters 1986) actions, mostly because of the short-term risks to hunting opportunity that such experimentation entails. It is important to understand, however, that the focus of AHM is on neither short-term harvest nor on learning, but instead on regulations that provide an optimal balance of short- and long-term harvest benefits. Of course, the realization of long-term benefits ultimately depends on an ability to learn more about the nature of regulatory impacts. Therefore, we have begun to explore how various management-system features influence learning rates and expectations for long-term management performance. However, this much is already clear, the degree of regulatory control over harvests has a marked influence on the efficacy of probing actions and, thus, on the learning required to improve management over time (Johnson and Williams 1999). This realization argues for regulatory alternatives that are sufficiently stable to provide the experience necessary for reliable and precise predictions of associated harvest rates.

We also see two other fundamental limitations on the ability to learn about regulatory impacts through the AHM process. The first involves the issue of replication and randomization of regulatory "treatments," and the associated impact on inferential strength (Nichols and Johnson 1989). In AHM, application of different regulatory alternatives occurs non-randomly because of the dependency of regulations on system state. Therefore, years with different regulations are characterized by systematic differences other than those associated with the regulatory treatment. This "statistical confounding" limits the confidence one can have that any observed effect was a consequence of differences in regulations. The ability to replicate regulatory treatments also is constrained because migratory birds do not form discrete populations that are spatially isolated. In the case of most waterfowl species, this means that replication of regulatory treatments occurs solely over time, thus limiting the strength of inferences about treatment effects and about the mechanisms underlying population dynamics.

The other limitation on learning involves the issue of system stability. It is at least conceivable that the model providing the most accurate description of population dynamics could change over time. For example, the mortality process in midcontinent mallards currently is characterized by two alternative forms, one assuming additive hunting mortality and one assuming a compensatory mortality process (Johnson et al. 1997). If the degree to which hunting mortality is additive to other sources of mortality depends on a density-dependent process (as virtually all scientists agree that it must), then changes in density (i.e., the number of birds per limiting resource) would result in changes in the most appropriate model. The ability of the AHM process to track these changes depends on both the magnitude and frequency of such changes (Johnson et al. 1993). If the changes in underlying population dynamics are too large or frequent, learning becomes essentially impossible because of limitations imposed by the precision of extant monitoring programs, and because of the role of past experience in the updating of model weights (Williams et al. 1996). We believe that the current AHM process for midcontinent mallards could suffer from this problem because there is evidence that the degree of additivity in hunting mortality has changed over time (W. L. Kendall, unpublished data).

Conclusions

Despite all of the limitations of the AHM process, it has proven to be incredibly valuable for providing structure and focus to the debate over appropriate hunting regulations. In the AHM process very little is left implicit, and managers are increasingly aware that disagreements over management objectives and possible outcomes cannot be "swept under the rug." Of course, AHM did not create these disagreements. They have been there all along, often manifesting themselves as contentious and bitter arguments over annual regulations. The great advantage of AHM is that it provides a means to agree on appropriate hunting regulations in the face of professional disagreement about the effects of hunting and other factors on waterfowl abundance. As we indicated earlier, however, AHM is not a process for resolving disputes over management objectives. Nonetheless, AHM can help inform and structure that debate by enabling managers to predict (probabilistically) in explicit and quantifiable terms the outcomes associated with alternative management objectives and constraints. For these reasons, we believe it may be the AHM process itself that is the most enduring benefit of the collective efforts to improve waterfowl harvest management.

Certainly, there is much more we could say about our experiences with AHM. Many of the lessons have been immediate and obvious (at least in retrospect), particularly those relating to the more technical aspects of the process. However, we believe the ultimate success of AHM will depend much more on how the management community reacts to the limits to management performance that are being exposed by the process. Therefore, we conclude our discussion by restating what we believe to be three key institutional issues that pose the greatest challenges to the long-term success of AHM.

1. *Goal setting.* Effective management planning and evaluation depends on agreement among stakeholders about how to value harvest benefits, and how those benefits should be shared. Unresolved value judgements, and the lack of effective procedures for organizing debate, pose a serious threat to the viability of AHM (or to any other informed approach to management). Moreover, the lack of information on the attitudes and preferences of the nation's waterfowl hunters is a continuing problem in the effort to determine appropriate management objectives.
2. *Limits to system control.* There are rather severe practical limits to the ability to predict, control, and measure harvests and, therefore, significant constraints on short-term harvest yields and the learning needed to increase long-term performance. These limits cannot be overcome completely, and the management community must somehow balance expectations with

reality in formulating regulatory strategies (Babcock and Sparrowe 1989).

3. *Accounting for sources of variation in waterfowl demographics.* The history of waterfowl management has been characterized by efforts to account for increasingly more spatial, temporal and organizational variability in waterfowl biology. We question the wisdom of this approach, particularly given that resources for monitoring and assessment are always limited. In addition to the limits imposed by management costs, managers must recognize that the ability to optimize harvests of various waterfowl stocks depends on the capabilities to harvest selectively, some understanding of each stock's dynamics, and knowledge of interdependence in stock sizes. Managers currently face considerable uncertainty in meeting any of these criteria.

Coping with these institutional issues will require innovative mechanisms for producing effective dialogue, and for handling disputes within a process that all parties regard as fair. Ultimately, we will consider AHM an unqualified success if it motivates and guides this process of institutional self-examination and renewal.

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Review of Archery Equipment Regulations for Big Game Hunting in the United States

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Both the number of bowhunters and the sophistication of archery equipment have increased significantly since the 1970s (Samuel et al. 1991). In contrast to the general decreasing trend in the number of total hunters and sale of hunting licenses in the United States, the number of big game hunters and the number of bowhunting licences sold have generally increased since the 1980s (U.S. Department of Interior and U.S. Department of Commerce 1997, Archery Manufacturers and Merchants Organization 1998). Bowhunting has become such an important aspect of wildlife management that The Wildlife Society recently published a technical review on the role of bowhunting in wildlife management (Kurzejeski et al. 1999).

In addition to the general upward trend nationwide in bowhunting participation, there has recently been an increase in the use of bowhunting to help control deer herds in urban and suburban communities of the United States (Kilpatrick and Lima 1999, Kilpatrick and Walter 1999). Indeed, the National

Bowhunter Education Foundation has even published a guide to help address the urban deer problem with the use of responsible bowhunting (Richter and Reed 1998).

Bowhunting now accounts for a substantial portion of the annual big game harvest in many states. State fish and wildlife agencies have developed a variety of archery equipment regulations in addition to archery season lengths and bag limits. These regulations are designed to ensure that the equipment used by bowhunters is adequate for the big game in question, to maintain the traditional nature of bowhunting and to ensure the safety of both nonhunters and hunters (Beattie 1983, Farmes 1983). More recently, regulations have been established to achieve a "fair" allocation of the available big game resource among different user groups (e.g., bow, muzzleloader, modern firearm). In some areas, the allocation of archery-only hunting opportunities has been decreased because bowhunters have taken an increasingly larger share of the annual harvest of some big game species (McDowell et al. 1993).

To determine the variability, specificity, purpose and general justification for archery equipment regulations, we conducted a survey of the 50 state fish and wildlife agencies. The results represent a description and assessment of archery equipment regulations in the United States as of the 1999-2000 hunting season. It is hoped that these data will serve as a source of information to assist states in developing and implementing uniform terminology and standards for archery equipment regulations, as well as identifying topics in need of research.

Methods

In June 1993, we sent a letter to all 50 state fish and wildlife agencies, requesting a copy of their current bowhunting regulations with emphasis on archery equipment restrictions. In addition, we asked the agencies to outline the justification or rationale employed in the formulation of these restrictions. We also requested copies of publications, staff reports and any historical information that might provide background on the current bowhunting regulations. In the absence of such material, the respondents were asked to provide their personal insights and those of appropriate staff members on the subject.

The technical information received from each state was reviewed, organized and listed according to similar archery equipment items and their regulations or restrictions. In 1995, the survey was repeated by sending the completed tables to the various state fish and wildlife agencies for their review and correction.

In 1999, we updated the archery equipment regulations for the 1999-2000 hunting season by conducting an Internet search of all 50 state fish and wildlife agencies' websites. We accessed the International Association of Fish and Wildlife Agencies' webpage (*http://www.sso.org/iafwa/documents/state_agencies_websites.htm*), from which we linked to the individual state fish and wildlife agency websites. We surveyed those archery regulations pertaining to deer (*Odocoileus* spp.) or big game and did not consider those pertaining to other species (e.g., small game, wild turkey [*Meleagris gallopavo*], etc.). Also, those archery equipment items for which a particular state specified a "recommended" standard were not included as part of that particular state's required regulations. Any state for which specific information on archery equipment regulations was incomplete or lacking was contacted by telephone to attempt to obtain a complete listing of all pertinent regulations.

Results and Discussion

All 50 states responded to our surveys, providing copies of current bowhunting regulations and, in most cases, information relating to the rationale behind the archery equipment restrictions. The information provided by the states revealed that there is considerable complexity and variability in archery equipment regulations. Much of this variation appeared to be in response to the type of big game hunted, agency perspectives, hunter preferences, and other special circumstances that were unique to a particular state or region. However, examination of the regulations revealed a number of similarities. After completing the Internet search, it was evident that several states had changed their archery equipment regulations pertaining to big game hunting since 1995. Therefore, only the regulations effective during the 1999-2000 hunting season are presented in this paper.

As shown in the summary of the results from our survey, a number of states did not address or regulate many archery equipment items (Tables 1 and 2). In many states, the use of a particular archery equipment item is permitted if that item is not specifically addressed or listed as "illegal" by a state's regulations. In other states with permissive codes, certain archery equipment items can be used only if they are specified as "legal." Based on our survey results, items that were listed as "legal" were generally the more controversial archery equipment items like chemical-tipped arrows and mechanical broadheads (Table 1) or crossbows and bow attachments (Table 2).

The use of poisons, chemicals or explosive arrow tips was listed as illegal by 42 states, was not specified in the regulations of 7 states, and was listed as legal in only 28 counties of 1 state (Table 1). Among all archery regulations listed for big game hunting, this one was most uniformly addressed by the 50 state fish and wildlife agencies. In the past, drug-tipped arrows were used by

Table 1. Summary of archery regulations pertaining to arrows used in big game hunting in the United States for the 1999-2000 hunting season.

State	Barbed broadheads[a]	Poisons or chemicals tips[a]	Mechanical broadheads[a]	Minimum broadhead width (inches) and minimum number of cutting edges
Alabama	NS	I	L	7/8" with 2 cutting edges[b]
Alaska	I	I	NS	7/8" with 2 cutting edges[c]
Arizona	NS	I	NS	7/8"
Arkansas	NS	I	NS	7/8"
California	NS	I	I	7/8"
Colorado	NS	I	NS	7/8" with 2 cutting edges
Connecticut	NS	I	NS	7/8"[d]
Delaware	NS	I	NS	7/8"
Florida	NS	I	NS	7/8" with 2 cutting edges
Georgia	NS	I	NS	NS
Hawaii	NS	I	NS	NS
Idaho	I	I	I	7/8" with cutting edge ≥0.015" thick[d]
Illinois	I	NS	L	7/8"[e]
Indiana	NS	I	NS	NS
Iowa	NS	I	NS	NS
Kansas	I	I	L	"all-metal cutting edges"[e]
Kentucky	I	I	NS	7/8"
Louisiana	NS	I	NS	7/8"
Maine	NS	I	NS	7/8"
Maryland	NS	I	NS	7/8"
Massachusetts	NS	I	NS	7/8"; but <1½"
Michigan	NS	I	NS	NS
Minnesota	I	I	L	7/8" with 2 cutting edges
Mississippi	NS	NS	NS	NS
Missouri	NS	I	NS	NS
Montana	NS	I	NS	2 cutting edges
Nebraska	NS	I	NS	NS
Nevada	NS	NS	NS	3/4"[d]
New Hampshire	NS	I	L	7/8"; but <1½"
New Jersey	NS	I	NS	3/4"
New Mexico	NS	I	NS	NS
New York	I	NS	L	7/8" with 2 cutting edges
North Carolina	I	I	NS	7/8"
North Dakota	I	I	NS	3/4" with 2 cutting edges
Ohio	NS	I	NS	3/4" with 2 cutting edges
Oklahoma	NS	I	NS	7/8" with 2 cutting edges
Oregon	I	NS	I	7/8"
Pennsylvania	NS	I	NS	"cutting edge design"
Rhode Island	NS	I	I	7/8" with 2 cutting edges
South Carolina	NS	L[f]	NS	NS
South Dakota	I	I	NS	7/8" with ≥3" long cutting edges
Tennessee	I	I	NS	NS
Texas	NS	I	NS	7/8" with 2 cutting edges
Utah	NS	I	NS	7/8" with 2 cutting edges
Vermont	NS	I	L	7/8" with 2 cutting edges
Virginia	NS	I	NS	7/8"
Washington	I	NS	I	7/8"[d]

Table 1. *Continued.*

West Virginia	NS	I	NS	3/4" with 2 cutting edges
Wisconsin	I	I	NS	7/8"
Wyoming	NS	NS	NS	1" g.

[a] NS = not specified in regulations; I = illegal; and L = legal.
[b] 24-inch minimum arrow length.
[c] 1-ounce minimum combined broadhead and arrow weight.
[d] 400-grain minimum combined broadhead and arrow weight.
[e] 20-inch minimum arrow length.
[f] Legal in 28 counties; illegal in 18.
[g] 400-grain minimum combined broadhead and arrow weight for big game; 500-grain minimum for elk and moose (*Alces alces*).

some bowhunters (Causey et al. 1978), but this hunting technique has been largely discontinued.

All but 10 states specified some aspect of broadhead characteristics in their archery equipment regulations for big game hunting (Table 1), presumably to help ensure the effectiveness (i.e., lethality) of equipment. Most states (36) did not specify a regulation pertaining to the use of barbed broadheads; 14 states listed this item as illegal (Table 1). Most states (38) did not specify a regulation regarding the use of mechanical broadheads, although seven states listed them as legal and five states listed them as illegal (Table 1).

There was substantial variation among states in the regulations pertaining to minimum broadhead width. Thirty states specified a minimum broadhead width of 5/8 inch; five states specified a minimum of ¾ inch; one state specified a 1-inch minimum, and two states set a maximum broadhead width of 1½ inches (Table 1).

There also was substantial variation among states in the terminology they used to regulate broadhead cutting edges. Most states (31) did not specify a particular cutting edge design, whereas 15 states required a minimum of two cutting edges (Table 1). The remaining four states specified either a minimum cutting edge thickness, "all-metal cutting edges," "cutting edge design," or a minimum cutting edge length (Table 1). It is likely that such inconsistent use of terminology in reference to broadhead cutting edges may create confusion among some bowhunters. By using more uniform terminology in their regulation of broadhead cutting edges, state fish and wildlife agencies would help avoid this possible confusion.

There appeared to be more variation among states in regard to their regulations of bows and bow attachments than for arrows. All states allowed the use of compound bows in addition to the more traditional long bow and recurve bow. For long, recurve and compound bows, 26 states specified only a minimum draw weight, 8 specified only a minimum arrow casting distance, 2 specified both draw weight and casting distance, and 14 did not specify either in their

Table 2. Summary of archery regulations pertaining to bows and bow attachments used in big game hunting in the United States for the 1999-2000 hunting season.

	Long, recurve and compound bows[a]		Crossbows[a]				
State	Minimum draw weight (lbs.)	Minimum arrow casting distance (yds.)	Archery season ?	Minimum draw weight (lbs.)	Telescopic sights[a]	Electronic devices[a]	Mechanical devices to hold bow at draw[a]
Alabama	35[b]	NS	DP	NS	I	I, LSPP	I
Alaska	NS	175	I	NS	I	I	I
Arizona	40 (deer) or 50 (buffalo)	NS	I	125[c]	NS	NS	I
Arkansas	40	NS	L[d]	125	I	NS	I, HHRP
California	NS	130	I	NS	NS	NS	I
Colorado	NS	NS	I	125[e]	NS	NS	I
Connecticut	NS	150	DP	25-200[f]	NS	NS	I, HHRP
Delaware	NS	NS	DP	NS	NS	NS	NS
Florida	35	130	I	NS	NS	I	I, HHRP
Georgia	40	NS	DP	NS	NS	NS	NS
Hawaii	45, 35, 30[g]	NS	NS	NS	NS	NS	NS
Idaho	40[h]	NS	DP	NS	I	I	I
Illinois	40	NS	DP	NS	NS	I	NS
Indiana	35	NS	I	NS	NS	NS	NS
Iowa	NS	NS	DP	NS	NS	I	NS
Kansas	45 (deer) or 50 (elk)[h]	NS	DP	125[i]	NS	I, LSPP	I
Kentucky	NS	NS	DP	NS	NS	NS	I
Louisiana	30	NS	DP	NS	NS	NS	I, HHRP
Maine	NS	150	I	NS	NS	NS	NS
Maryland	30	NS	DP	NS	NS	NS	I, HHRP
Massachusetts	40	NS	DP	NS	NS	NS	NS
Michigan	NS	NS	DP	NS	NS	NS	NS
Minnesota	40	NS	DP	NS	NS	NS	I, HHRP
Mississippi	NS	NS	DP	NS	I	NS	NS
Missouri	NS	NS	DP	NS	NS	I, LSPP	I, HHRP
Montana	NS	NS	I	NS	NS	I	I, HHRP

Table 2. Continued.

State	Long, recurve and compound bows[a]		Crossbows[a]		Telescopic sights[a]	Electronic devices[a]	Mechanical devices to hold bow at draw[a]
	Minimum draw weight (lbs.)	Minimum arrow casting distance (yds.)	Archery season ?	Minimum draw weight (lbs.)			
Nebraska	40	NS	DP	NS	NS	I, LSPP	I, HHRP
Nevada	NS	150	NS	NS	NS	NS	NS
New Hampshire	40	NS	DP	NS	NS	NS	I, HHRP
New Jersey	35	NS	DP	NS	NS	I, LSPP	I, HHRP
New Mexico	NS	NS	I	NS	NS	NS	L
New York	NS	150	DP	NS	NS	NS	NS
North Carolina	45	NS	DP	150	NS	NS	NS
North Dakota	NS	130	DP	NS	NS	I	I
Ohio	40	NS	L	75-200[j]	NS	I	I
Oklahoma	40	NS	DP	100	NS	NS	I, HHRP
Oregon	40 (deer) or 50 (elk)[h]	NS	NS	NS	NS	NS	NS
Pennsylvania	NS	NS	DP	125-200	L	I	I, HHRP
Rhode Island	40	NS	I	NS	I	I, LSPP	I, HHRP
South Carolina	NS	NS	DP	NS	NS	NS	I
South Dakota	40	NS	DP	NS	I	NS	I
Tennessee	NS	NS	DP	NS	NS	NS	NS
Texas	40	NS	DP	125[j]	NS	NS	I
Utah	40	NS	DP	125[k]	NS	NS	I, HHRP
Vermont	NS	NS	DP	NS	L	NS	I
Virginia	NS	125	DP	NS	L	NS	I, HHRP
Washington	40[h]	NS	I	NS	NS	I	I
West Virginia	NS	NS	I	NS	NS	NS	NS
Wisconsin	30	NS	DP	NS	NS	I, LSPP	I
Wyoming	40 (big game) or 50 (elk/moose)	160	L	90[e]	NS	NS	NS

See next page for footnotes.

[a] NS = not specified in regulations; I = illegal; L = legal; DP = permitted for disabled persons only; LSPP = lighted sight pins permitted; and HHRP = hand-held releases permitted.
[b] 75-percent maximum letoff for compound bows.
[c] 16-inch minimum draw length.
[d] Crossbows prohibited for hunting elk.
[e] 16-inch minimum bolt length and 14-inch minimum draw length.
[f] 450-grain minimum weight for combined safety, bolt and broadhead.
[g] 45 lbs. for long bows, 35 lbs. for recurve bows and 30 lbs. for compound bows.
[h] 65-percent maximum letoff for compound bows.
[i] 16-inch minimum bolt length.
[j] Stock not less than 25 inches in length.
[k] 18-inch minimum stock length.

regulations (Table 2).

Most states (47) prohibited the use of crossbows during the archery season; crossbows were legal in only three states, one of which prohibited their use for elk (*Cervus elaphus*) hunting (Table 2). Crossbows generally are assigned to a period outside the special archery season (Riehlman and Stang 1993) or can be used by hunters during the regular firearm season in most states. Most states (32) made exceptions for disabled persons and permitted them to use crossbows for big game hunting during archery season, but 12 states specifically listed them as illegal for anyone to use (Table 2). Only 12 states listed a minimum draw weight for crossbows (Table 2).

Feedback from the agencies regarding the rationale behind the formulation of archery equipment regulations was revealing. The majority of states (37) either specifically indicated or inferred that the rationale behind archery equipment restrictions for bowhunting was to ensure the effectiveness (lethality) of the equipment in harvesting the target animal in an efficient and humane manner. However, more than half of the states (28) indicated that maintaining the "traditional" status of bowhunting was a major purpose of equipment regulations. This tendency was reflected in efforts to minimize equipment advances and "gadgets" to maintain some perceived level of difficulty and tradition historically associated with bowhunting. For example, 7 states prohibited the use of telescopic sights, 16 states prohibited the use of electronic devices (e.g., laser-type sights that project a beam of light onto the target), and 32 states prohibited the use of mechanical devices that hold a bow at partial or full draw (Table 2).

Conclusions and Recommendations

Although all states permitted the use of compound bows, many restricted the use of "perceived gadgets" to maintain "a level of difficulty" associated with bowhunting. In addition, more than half of the states indicated that maintaining the "traditional" status of bowhunting was a significant consideration in the development of archery equipment regulations.

Our survey indicates that there is a lack of consistency and standardization of archery equipment terminology and regulations among the state fish and wildlife agencies in the United States. This lack of consistency may result in confusion among the hunting public, especially for those persons who hunt in multiple states. The high degree of variation in archery equipment regulations among states appeared to be the result of attitudes and opinions held in the past, rather than based on any objective analysis of the performance of specific archery equipment or its effect on the big game resource. For example, draw weight may not be an accurate measure of a bow's power, especially considering the new design of bows and concentric wheels on bows (i.e., a 30-pound bow today may have more power than a 60-pound bow of the 1970s). Thus, states that only specify a minimum draw weight without further elaboration may be overly restrictive in their regulations. These unintentional restrictions may limit recruitment of young hunters and women into bowhunting.

Kurzejeski et al. (1999) also noted the lack of objective data on bowhunter preferences and expectations in relation to archery equipment, bowhunting opportunities and harvest success rates. Generally, the responses to our survey also reflected the need for a more objective approach to developing archery equipment regulations. Therefore, we recommend that an interdisciplinary committee of agency biologists, managers, bowhunters, and archery industry representatives be formed to accomplish three objectives: (1) to help identify areas of needed research on archery equipment items; (2) to recommend minimum equipment standards for bowhunting that can serve as a guide to those states interested in developing more uniform archery equipment regulations; and (3) to identify needed research on bowhunter motivations, preferences and expectations relative to the new technological developments in archery equipment, and how these developments may affect harvest success rates and hence archery hunting opportunities.

Acknowledgments

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A Review of Regulation-setting Processes Among State Wildlife Agencies

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A recent review of regulations regarding methods of take for archery deer hunting revealed a number of inconsistencies across states (Mayer et al. 2000). For example, minimum broadhead widths, design of broadheads and minimum standards for bow draw weights were found to vary, yet it is assumed that each of these differing standards was set to achieve the same goal—lethal effectiveness. Such inconsistencies may create a number of consequences. An immediate concern is whether the regulations are all meeting their intended goals. Of equal concern would be impacts on hunters and other stakeholders. For example, inconsistency can jeopardize the credibility of wildlife harvest laws among hunters. It can create difficulties for nonresident hunters who unknowingly fail to comply with regulations. If inconsistency reflects ineffective or unneeded regulations, it may unnecessarily restrict choice and, therefore, reduce recreational opportunity and quality.

Variations in equipment regulations among states may be justified to meet differing regional needs. However, inconsistencies may also be due to subjective aspects of regulation setting in state agencies. In some cases, states may derive different conclusions when there is insufficient technical information available to thoroughly and accurately evaluate proposed regulations. Inconsistent regulations among states may also result if processes to evaluate regulation proposals are inadequate. For example, the processes could fail to evaluate regulation proposals systematically using standardized criteria.

This study investigated the general regulation-setting processes and associated criteria used in state wildlife agencies to explore the hypothesis that a systematic application of predetermined and accepted criteria in regulation setting processes has not been widely used. Griese et al. (2000) have proposed that the application of criteria in some consistent format should be a part of a systematic evaluation process and that a systematic use of criteria would: (1) make the process accountable to stakeholders; (2) identify and direct political forces; (3) identify future research needs; and (4) ultimately enhance the credibility of the agency and acceptability by the public.

We also were interested in the role of the wildlife agency in the evaluation and decision-making process. Although regulation setting is often an intensely political process, we assumed that wildlife agencies would be charged with providing the scientific basis for any evaluation. Given that science is defined as much by the process it uses as by the product it creates (i.e., knowledge), it is reasonable to expect that a science-based evaluation would include a systematic and consistently used approach on which to base political deliberations.

It was not the intent of this study to describe empirically the rule-setting processes of all states investigated. Nor could our interviews quantify the use of criteria and their effectiveness. The real purpose of this report was to pose—not answer—the question of whether our states' processes for setting wildlife use regulations are adequately systematic and defensible.

Methodology

Pilot interviews were conducted with staff of three state agencies attending the 1998 Midwest Fish and Wildlife Conference in Cincinnati. Telephone interview questions then were developed for use in summer and fall 1999. Including the three pilot states, six states were randomly selected from each of the four North American fish and wildlife regions, and designated representatives were interviewed regarding the processes used in that state to evaluate and set regulations.

Of the 24 wildlife agency chiefs/directors we initially called, four did not return our requests for an interview and replacement states were randomly selected from those regions. Two of the interviews involved the chief/director of the agency, and the remaining 22 were scheduled with another staff person designated by the chief/director as having expertise regarding the regulation setting process in that state. The interviewees included 10 assistant division chiefs, six wildlife biologists charged with the regulations for specific species, four state rules coordinators, and two legal counsels. There did not seem to be any correlation between job classification and responses. For example, one of the directors interviewed was highly enthusiastic about the idea of a systematic use of criteria, while the other director interviewed was highly critical of the idea, noting that ". . . commission meetings did not lend themselves to a checklist."

Prior to the interview, participants were mailed an overview of the research, the interview questions and a list of evaluation criteria to guide discussions. Interviews were taped with permission. Interview length ranged from 30 to 65 minutes.

The use of only one agency expert imposed some limits on our attempt to understand the regulation setting processes in that state. For example, while each interviewee was selected as a qualified "expert," they reported varying degrees of involvement in their state's regulation processes and knowledge of how and what criteria were used. We believe the descriptions of the regulation processes they provided are adequate for the purposes of this investigation. We have tried to properly interpret instances where perspectives seemed to reflect the background and experience of the interviewees. To minimize error, interview information was checked against the *State Wildlife Laws Handbook* (Musgrave and Stein 1993), which summarizes the overall department structure in each state. Also, in many cases, interviewees were contacted again for clarification.

A hypothetical method of take (MOT) that would be new for each state was proposed to allow some comparison among states (e.g., use of atlatl for taking deer). Interviewees were asked to describe the procedures by which this proposal would be evaluated.

An indication of the variability among states was the difference in terminology they used to describe the process. The terms "rules" and "regulations" are technically defined somewhat interchangeably with "rules" referring to a broader establishment of a "standard, guide or regulation." Regulations are "rules of order. . .prescribed by. . .authority. . .relating to action of those under its control" (Black 1968). There appears to be no standard use of the terms among states. In some states, rules required approval only by the agency or its commission, whereas regulations were set by legislative authority. Other interviewees used the terms interchangeably and made no such distinction. For the purpose of this paper, only the term "regulation" is used, regardless of authority or how it was defined by a state.

The organization that had authority to make decisions or make recommendations to an external body also varied (Table 1). For consistency, the administrative arm that deals with wildlife has been called "agency" whether that authority is with a smaller unit (e.g., the "bureau" or "division") or lies with the parent organization or department.

To provide a measure of anonymity, examples are seldom identified with individual respondents and states. Any errors in representing the findings are the responsibility of the authors' interpretation and not that of the interviewees.

Results

Regulatory Processes

Interviewees were asked at what points in the regulation process evaluations of proposed regulations occurred and whether these evaluations were systematic and consistent. The process varied among states and even within a state depending on the nature of the regulation proposal. A brief summary of

Table 1. Summary of interviews concerning the regulation setting processes of state wildlife agencies.

State	Structure of wildlife agency	Public representation[a]	Authority for setting MOT regulations[b]	Role of agency in regulation process[c]	Criteria used in regulation process[d]	Would/does systematic criteria improve the current regulation process?[e]
Western Association						
Alaska	Div. Wildlife Conservation in Dept. Fish and Game	Board	Board	Consistent advisory	Assumed and legal criteria as outlined in statute	Yes
Arizona	Game and Fish Dept.	Board	Board	Consistent	Assumed	Yes
Colorado	Div. Wildlife in Dept. Natural Resources	Board	Board	Consistent advisory	Internal directive and commission brochure	Yes
New Mexico	Wildlife Div. in Dept. Game and Fish	Board	Board	Advisory	Assumed	Yes
Washington	Dept. Fish and Wildlife	Board	Board	Consistent advisory	Assumed	Yes
Wyoming	Wildlife Div. in Game and Fish Dept.	Board	Board	Primary determinant	Assumed	Yes
Midwest Association						
Arkansas	Wildlife Div. in Game and Fish Commission	Board	Board	Consistent advisory	Assumed	Yes
Illinois	Wildlife Div. in Dept. Natural Resources	Legislative Sportsmen's Caucus	NA[f]	NA[f]	Assumed	NA[f]

Table 1. Continued.

State	Structure of wildlife agency	Public representation[a]	Authority for setting MOT regulations[b]	Role of agency in regulation process[c]	Criteria used in regulation process[d]	Would/does systematic criteria improve the current regulation process?[e]
Iowa	Wildlife Bur. in Dept. Natural Resources	Board	Board	Consistent advisory	Assumed	No
Missouri	Wildlife Div. in Dept. Conservation	Conservation Federation	Board	NA[f]	Contained in "Allocation of Resource Guidelines"	NA[f]
Ohio	Div. Wildlife in Dep. Natural Resources	NA[f]	NA[f]	NA[f]	Assumed	NA[f]
South Dakota	Wildlife Div. in Game, Fish and Parks Dept.	Board	Board	Consistent advisory	Assumed but moving toward formal list	Yes
Northeast Association						
Connecticut	Div. Wildlife in Dept. Environmental Protection	Citizens' advisory council	Commissioner	Primary determinant	Assumed	Yes
Massachusetts	Div. Fisheries and Wildlife in Dept. Environmental Management	Board	Board	Consistent advisory	Assumed	No
New Hampshire	Wildlife Div. in Fish and Game Dept.	Board	Board	Consistent advisory	NA[g]	NA[g]
Pennsylvania	Bur. Wildlife Management in Game Commiss.	Board	Board and legislature	Consistent advisory	Assumed	Yes

Table 1. Continued.

State	Structure of wildlife agency	Public representation[a]	Authority for setting MOT regulations[b]	Role of agency in regulation process[c]	Criteria used in regulation process[d]	Would/does systematic criteria improve the current regulation process?[e]
Vermont	Div. Wildlife in Agency of Natural Resources	Board	Legislature	Consistent advisory	Implied by species plan and legislative directive	No
New York	Bur. Wildlife in Dept. Environmental Conservation	Conservation Fund advisory board (legislative board)	Commissioner and legislature	Primary determinant in commissioner process, consistent advisory in legislative process	Assumed	Yes
Southeastern Association						
Florida	Div. Wildlife in Fish and Wildlife Conservation Commiss.	Board	Board	Consistent advisory	Originator's form used in agency review	Yes
Georgia	Wildlife Resource Div. in Dept. Natural Resources	Board and (legislative) natural resource committee	Legislature	Consistent advisory	Assumed	Yes
Louisiana	Wildlife Div. in Dept. Wildlife and Fisheries	Board	Board	Consistent advisory	Assumed	Yes
Oklahoma	Wildlife Div. in Dept. Wildlife Conservation	Board	Board	Consistent advisory	Implied in agency mission statement	No

Table 1. Continued.

State	Structure of wildlife agency	Public representation[a]	Authority for setting MOT regulations[b]	Role of agency in regulation process[c]	Criteria used in regulation process[d]	Would/does systematic criteria improve the current regulation process?[e]
South Carolina	Wildlife and Fresh Water Fisheries Div. in Dept. Natural Resources	Board and Senate Game and Fish Cmmtt. and Ag. and Natural Resource Committee	Legislature and board	Consistent advisory	Assumed	Yes
West Virginia	Wildlife Sect. in Dept. of Natural Resources	Board and House and Senate Natural Resource Cmmtt.	Legislature	Consistent advisory	Assumed, also some external administrative rules criteria	No

[a] This illustrates the variety of ways the public was represented in the resource management process through their elected legislators and/or appointed boards of commissioners (boards) or advisory groups. Advisory groups could be composed of legislators or citizens.

[b] Although policy setting in some states is variable and difficult to summarize accurately, this column indicates the decision-making body which has the primary authority to make final decisions on a regulation relating to method of take: board = board of commissioners.

[c] Responses to " How would you describe the wildlife agencies role in the regulation setting process for proposals regarding method of take?": "primary determinant" = primary determinant of the outcome; "consistent advisory" = advisory only, but a consistent part of the process and with considerable influence; "advisory" = advisory only but not always consulted as part of a well defined systematic process.

[d] Criteria noted by interviewees: "assumed" indicates no written criteria existed, but all criteria were assumed by the interviewee to be considered.

[e] Interviewees who responded "a formal list of criteria will improve the regulation process in their state" in *at least* one of the following: the use of appropriate data and science in evaluating proposals; the consideration of priorities in making final decisions; communication and clarification during the evaluation process; the ability to justify regulation decisions to constituents.

[f] Pilot interviewees were not asked these questions.

[g] Interviewee did not feel knowledgeable in the entire process to answer these questions with certainty.

these processes is presented here to illustrate the diversity involved and to provide some insight regarding the status of a systematic use of criteria in the evaluation process.

The processes for setting regulations were described as stable and unchanging by all but four states. In one state, recent political decisions changed the regulation-setting process. Two other states reported current attempts to reorganize the regulation-setting process into something "less chaotic." In the fourth, the regulation-setting process reportedly was tied to a highly political and dynamic environment that created instability in the process itself.

Organizational structure for regulation setting. Organization of the decision-making bodies involved in wildlife management varied among states (Table 1). In some states, the wildlife management structure is a department within itself, in others it is a division of a larger state department. Most, although not all, states have a commissioner or board of commissioners appointed to represent the public in the management process. In some states, the legislative body has delegated some or most authority to regulate wildlife and is not involved in the "normal" process. In other states, the legislature is a primary player in the process.

Authority for making regulation decisions also varied among states. Decisions were made by the wildlife management administrators in some states, and by the state department directors or by commissions in others. In some states, authority for decisions also could vary by type of regulation. In Michigan, a public ballot initiative transferred the authority to make specific *wildlife* regulation decisions from the Director of the Department of Natural Resources to the Natural Resource Commission. However, the authority to make similar types of regulations for *fisheries* management still resides in the Director. The role of the professional wildlife managers in setting the regulations ranged from advisory to decision maker among states interviewed.

Phases of the regulation process. While no two states had the same regulation-setting process, three broad regulation-setting phases could be discerned: (1) the regulation proposal phase; (2) the evaluation and recommendation phase; and (3) the decision-making phase. The type and number of steps taken in each of these phases depended on the nature of the regulation, who had statutory authority over the proposed regulation, and the steps a state had to follow because of formal administrative rules (e.g., public meetings).

1. Regulation proposal phase. Both formal and informal methods of submitting proposals for regulations were described. Formal, written documentation to introduce regulation proposals was not mandatory in most states contacted. The majority of the interviewees (20 of 24) indicated that originators of a regulation need only propose a change to an agency staff person to initiate the process. In these cases, the staff person often was

the first to decide whether the proposal was forwarded. A third of the interviewees (8 of 24) reported that many potential regulations were identified during informal public meetings held to identify emerging issues. Nine states indicated that the public could introduce a proposal directly to the decision-making body (e.g., the natural resource commission, director of the agency).

Only four states required the originator of a proposed regulation to submit a written request for a new regulation. Of these, two required the petitioner to provide their own evaluation of the new regulation. These "petitions" influenced the agencies' decisions to forward the proposal through the decision-making phase.

2. Evaluation and recommendation phase. The evaluation and recommendation phase in all states involved some hierarchy of decision makers, and many included some form of intra-departmental or intra-agency review team. In some states, reviews at various levels within the agency constituted a series of "filters" when making evaluations of proposed changes. Often, the first filters were at the regional or management unit level where the biological (and sometimes political and socio-economical) consequences of the proposal were evaluated. The proposal was then sent to senior staff, which is the level most likely to evaluate the political and socio-economic impacts of the proposed change. Most interviewees in states with the hierarchical review believed this evaluation effectively considered all appropriate criteria in the process. One interviewee believed that biologists sometimes overlooked criteria such as the administrative burden imposed by the change in their initial evaluation process; the assumption being that these criteria would be addressed at higher administrative levels. However, the application of criteria by each level appeared to be assumed and not formally assigned in most states.

   Sixteen of 24 interviewees reported some form of "intra-departmental" regulation committee (e.g., comprised of representatives of law enforcement, information and education, fisheries, administration and/or finance/budgeting). Intra-agency committees (e.g., comprised of wildlife staff representing biologists, technicians, and/or conservation officers) also were reported by 12 of the states, although intra-agency and intra-departmental committees were not mutually exclusive. Again, the assumption was that the collective expertise would address all appropriate criteria in evaluating proposed regulations. Two states reported that in lieu of a committee, new regulation proposals were submitted to the entire wildlife staff for review. These reviews were compiled and included in the evaluation process.

3. The decision-making phase. The authority to make final decisions resided with boards of commissioners, legislatures and/or single commissioners (Table 1). For MOT regulation changes, procedures for making final decisions varied both within and among states. For example, in two states, authority to make a final decision on a MOT regulation depended on whether it involved private or public land, and the species in question.

   A board of commissioners was most often the decision-making authority among our study states, but there were variations. Three states reported a single commissioner (director) system rather than a board. The boards in 10 of the states made many other natural resource regulations (e.g., commercial and sport fishing, forest management, boating, parks) as well as those relating to wildlife. Whereas 21 states indicated that they had boards of commissioners, only 13 of these boards had constant regulatory authority for a new MOT regulation. For the remaining eight states MOT was always a legislative matter. Depending on the species in question (i.e., big or small game) or where the method of take was to be applied (e.g., public or private lands), the legislatures of 3 of the 13 states with boards only sometimes had regulatory authority for regulations concerning MOT.

   Many boards asked for a recommendation from the wildlife agency on the acceptability of the proposal. One interviewee stated that the board in his state assumed that "the agency had done all its homework" prior to a proposal being brought to them. However, two experts indicated that their boards could—and sometimes did—vote on a proposal at the time of its presentation. The regulation process in these two states was not governed by an administrative procedures act that mandates additional public input in the regulation process.

   Some agencies presented their recommendations to boards formally in writing, others made only an oral presentation. Only nine of the interviewees stated that their board required a written synopsis of a proposed regulation prior to board meetings when decisions were made. One interviewee believed the boards did not want to be burdened by paperwork, while another stated that their board wanted as much information as they could obtain.

   While most state wildlife agencies with boards of commissioners felt that they had good working relationships with their boards, only one of the interviewees working under the board process felt that their wildlife agency was the primary determinant in the outcomes of proposed regulations. In three states where agencies worked under the auspices of a single decision maker (either a commissioner or department director) the interviewees indicated the wildlife agency recommendation was the primary factor influencing the outcome of proposed regulations decided on by the commissioner or agency.

In 11 of the states interviewed, legislatures had retained authority to change regulations regarding some or all MOT. Only five of these indicated that their legislatures had some form of natural resources/wildlife committee to review proposed regulations prior to vote by the legislature. One interviewee indicated that their agency had a good rapport with the chairman of the legislative natural resources committee and "hopefully" they would be asked for input on a proposed MOT change. However, other agencies reported considerably less opportunity to have input into the legislative process.

Criteria in the regulatory processes. Variations described for the three regulation phases have important implications for the systematic use of criteria in the regulation-setting processes. Of the 24 states, only interviewees in Missouri, Florida and Colorado indicated that they had used a formal list of criteria in the evaluation of proposed regulation changes. The remaining interviewees reported that their internal/agency phases were structured such that all relevant criteria would usually be considered, even though they lacked a documented, formal list of criteria.

Of the states interviewed, Florida's "Originator's Form: Recommendation for Proposed Rule Change" best approached a comprehensive list of criteria. The mandatory use of this form was adopted in Florida to guarantee that all criteria are considered in every evaluation. The form was reported to be very important for decision makers because it enabled them to consider a comprehensive evaluation of any proposed regulation. Another reported benefit of this formal set of criteria was that it helped to reduce disruptive controversy over the board of commissioner's actions. The prescribed use of criteria reportedly provided the commissioners a more thorough and defensible basis for decisionmaking, even when proposed changes were highly contentious.

In Florida, a proposed change and evaluation form could be submitted by individual staff or by staff on behalf of a stakeholder. The following questions were included on the form to guide the evaluation.

- Will the regulation impact an existing or other proposed rules?
- What is the problem that the regulation will solve?
- Will the regulation impact wildlife populations, harvest, harvest per man (sic) day, man days of hunting, the number of hunters, the length of season, number of nonconsumptive users or man days of nonconsumptive use?
- What is the biological basis of the regulation?
- What is the social/political impact of the regulation?
- What is the economic cost and/or benefit to the segments of the public affected by the regulation?

- What additional agency equipment, manpower or operating funds will the change require?

Some states reported that criteria to guide evaluation of proposals could be identified in the language of various documents. One interviewee indicated that the criteria used in their proposed regulations were implied in strategic planning documents which stipulated broad goals such as "to have a large and healthy deer herd." In another state, criteria were reportedly implied by the mission statement of the agency.

Attitudes regarding a proposed use of criteria. To facilitate interviews, a list of questions representing a set of criteria for evaluating proposals was sent to each participant (Table 2) (Griese et al. 2000). The criteria were expressed in question format to guide evaluation and assumed that the agency would define a standard to establish the criterion. For example, the question, "Are there unacceptable risks to life or property?" implied that the evaluator (decision maker) had defined some standard beyond which the risks were not acceptable.

Interviewees were asked whether this list of questions were included in the process of evaluating proposed regulation changes in their state. All interviewees believed their current methods of evaluation with hierarchal and/or intra-departmental/agency review teams resulted in the consideration of each of the criteria we posed. One state wildlife director stated that all of the proposed criteria were "intuitively" considered in their process. Most believed the list was comprehensive but some experts suggested additional criteria, including: (1) the new MOT must not compromise the concept of fair chase; (2) the

Table 2. Criteria presented to interviewees for consideration (adapted from Griese et al. 2000).

1. Need: is the need clearly defined? Does it address a real or perceived problem?
2. Wildlife population and biological impacts: does this regulation contribute to or interfere with desired population management goals or objectives?
3. Safety: what are the risks to life or property affected by the regulation? Will the risk to life or property be within current levels of public tolerance, or will unacceptable risk be introduced?
4. Allocation: does this regulation result in a change in allocation of harvest and/or opportunity? If yes, is this change perceived as reasonable and fair by stakeholders?
5. Compliance (ability to be enforced): is the regulation easily understood by the user and is it practical in its ability to be enforced in the field?
6. Harvest efficiency (lethality): does this regulation measurably change the rate of recovering the animal?
7. Public perception and reaction: e.g., do the human dimensions data show that the regulation is understood and accepted by appropriate stakeholders?
8. Administrative burden: can the agency afford to enforce or administer this regulation at the level required to be effective? What are the agency costs?

new MOT must comply with other state regulations; and (3) the new MOT must not adversely affect other species. Safety was not thought a criterion for two states, as safety was outside the constitutional authority of the wildlife agency.

Identified need for improving the evaluation process. When asked whether a systematic application of such a list would be useful in their state's process, most (16 of 24) believed it would improve communication and clarification during the evaluation process and improve justification of regulation decisions to constituents. Only 11 agreed that a list of criteria would improve the use of appropriate data and science in evaluating proposals. Those who disagreed believed that their current informal application of all criteria by hierarchical review and/or intra-divisional teams, already appropriately used available data and science.

Eight interviewees agreed that a formalized list would improve the consideration of priorities in making final decisions in their state. Nine others responded that priorities were determined naturally in the current decision-making process. Another argument offered by two experts was that final decisions would be made by decision makers with whatever priorities they believed were important—biological, sociological, or political—and that a more systematic application of criteria in the process would not influence that outcome. When asked about the priorities which would be placed on the criteria we offered, most of the interviewees agreed that this would change depending on the specific regulation being proposed. Most believed that the biological concerns would ultimately be given priority in their agencies (i.e., the integrity of a species would never knowingly be jeopardized in developing a regulation).

Conclusions

Griese et al. (2000) have proposed that use of formally established criteria in a systematic evaluation of proposed regulation changes could provide several benefits. We hypothesized that such a system was not currently used by most state agencies, which appeared to be the case. Although agencies were using criteria in some form, most did not report any explicit effort to formalize criteria. Only one state of the 24 we sampled reported using the approach of systematically applying standard criteria and documenting evaluation results in some part of in their process. A few experts reported that criteria were inherent in the goals established in planning documents such as species management or strategic plans. Most states relied on a review process involving several hierarchical levels and/or external committees to introduce and apply appropriate criteria. Although most experts were comfortable that their review processes appropriately considered a full range of criteria, most of them (18 of 24) believed some benefits in the area of communication and documentation could be gained by adopting a more formal use of criteria in their state.

The role of the wildlife management professionals in the process of evaluating and deciding MOT regulations was generally reported to be advisory but ranged among states from merely providing input to being a primary determiner of the outcome. Similarly, their role in formulating procedures for regulation decision making appears to range from none to nearly autonomous. Most experts reported that their agencies had a "good" relationship with decision makers and believed they appropriately influenced at least the decisions based on science.

Considerable political stakeholder activity associated with regulation-setting processes was reported by most experts. Such political activity did not always support or allow a deliberative consideration of data, especially when those data were not compelling and/or proposals were highly contentious. Use of a systematic and well-documented application of accepted criteria also may reduce the level of associated issue activity. Experience in public involvement has shown that generally people are more willing to accept unpopular decisions when they are convinced the decision was made fairly and appropriately (e.g., Creighton 1981). Our interviews with states suggested that decision making and the criteria being applied might not always be made clear to the public being asked to accept those decisions. Although adoption of the approach proposed here may not resolve all of these difficulties, many interviewed experts believed it could make an important contribution in communicating with stakeholders.

Political activity plays a critical role in setting priorities to be used in the final decision regarding proposed regulation changes. Although setting (as opposed to evaluating) the priorities in management is beyond the scope of science, presenting a clearly defined and evaluated set of criteria to those engaged at the political level in sorting through competing values and priorities might enhance that process.

The hierarchical reviews currently popular among state agencies may not encourage a comprehensive consideration of all criteria at each level nor provide comprehensive documentation. Most experts indicated that each level brought its own set of criteria to the review process. A formally established set of criteria which are tracked through the entire process from initiation to decision (similar to that reported to be used in Florida) could help ensure that each level considers all appropriate criteria. A more structured approach also may help to reduce impacts on the quality of the evaluation from turnover among agency personnel at various levels by creating a more stable institutional memory.

It is reasonable to infer that current processes for deciding regulation changes could contribute to the lack of consistency among regulations described across and sometimes within some states. Although findings are limited, given the state of management as it appeared through our interviews, and the potential benefits proposed by Griese et al. (2000), it seems prudent for wildlife agencies to review their roles in the evaluation of proposed regulation changes. For some states, it may be that adopting a more formal means of evaluating, documenting and reporting wildlife agency evaluations would improve the actual decision making, even those which are highly political and where the agency role is limited.

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Review of Criteria and Procedure and Recommendations for TighteningRegulation-setting in State Wildlife Agencies

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Wildlife agencies, wildlife commissions, boards or other regulatory bodies (grouped as "agencies") are tasked with formulating and/or evaluating proposed changes to laws, rules, regulation or statutes (grouped as "regulations"). Bull and Peyton (2000) suggest that agencies assigned this task do not always evaluate proposed changes with measured consistency. Beattie (1983) implied that an absence of standard criteria from which to evaluate regulations made the agency susceptible to pressures from special interest groups.

When regulatory bodies fail to rely on a process that is methodical, and which develops decisions based on data, quantified observations and expert opinion, and/or is appropriately documented and communicated, user groups may interpret decisions as unfair and unjust (Bacow 1980, Bleicker and Bleicker 1990). Nonmethodical processes represent a "black box" to stakeholders who are unaware of what information was used or how criteria were weighted for the final decision (Wondolleck 1985). If this interpretation causes some special interest groups to circumvent the regulatory body, it poses real risks that the decision will not be the most equitable for stakeholders or most appropriate for the resource in question. We propose that a broadly applicable and assiduous evaluation process that considers widely accepted criteria can help avoid those pitfalls by establishing a clear process that is fairly applied.

We use bowhunting regulations to illustrate the application of criteria. Agencies have struggled when evaluating bowhunting equipment effectiveness because little organized supporting data exists. This struggle is evident in the inconsistencies in equipment restrictions across similar states (Beattie 1983, Mayer and Carlson 1993, Mayer et al. 2000). Mayer et al. (2000) found that most agencies responsible for these widely diverse restrictions desired their bowhunting equipment regulations to "insure the effectiveness (lethality) of the equipment to take the target animal in an efficient and humane manner," while also striving to maintain bowhunting's primitive weapon status.

Why a Standardized Evaluation?

Clearly delineated criteria and processes during regulation-setting provide a forum for clarifying difficult policy questions and can help: (1) make the process accountable to stakeholders; (2) identify and direct political forces; (3) identify future research needs; and (4) ultimately enhance the credibility of the agency and acceptability by the public.

The benefits of a standardized evaluation to the public, the resource and the agency could be significant. A thorough agency evaluation could minimize the need for future changes and reduce unnecessary periodic changes in regulations. A permanent record can provide benefits in the form of better stakeholder understanding of the process of regulation setting. If a formal list of criteria guided the process and evaluations were recorded and made available, the formal record could be used to communicate the process and decision to concerned stakeholders. Over time, a consistently used process would further benefit stakeholders who would understand how to enter into the process. Formal criteria could also focus stakeholder input during the evaluation process and make debates more productive.

Roles of Science in the Regulation-review Process

Four basic processes are involved in the evaluation of proposed regulation changes. First, there must be identification of, if not agreement on, what attributes will be evaluated. Second, an acceptable criterion level must be established for use in evaluating the attributes. The third process is the actual evaluation of the proposal using available information and experience. Fourth, the evaluation must assign some relative importance to each identified criterion in making the final decision (i.e., the criteria must be weighted in the decision process).

Identifying available information, creating new information and helping to define the remaining level of uncertainty for agencies making decisions have been the traditional roles of science. The tasks of setting criterion levels and establishing weights for making decisions are clearly social value judgments and ultimately fall within the realm of politics and the art—rather than the science—of management. Political decision-making must begin where science ends. Unfortunately, science, which provides (often inadequate) databases and interpretations for evaluating proposals, often ends prematurely. There will always be a need for informational products of scientific research in management issues, however, there may be a larger role for science.

Walters (1986) has argued for improving the role of science through an adaptive management approach to more effectively manage uncertainty in resource management. He proposed that management decisions could improve future decisions when appropriate scientific data gathering and analysis are used to evaluate decisions. Franklin (1995) called for wildlife professionals to take a stronger role in determining wildlife resources policy. In addition to providing information directly to the policy-setting political processes, he advocated increased political action by the professional organization and individuals. Our proposal takes yet another direction.

We propose that wildlife professionals are obliged to find ways to make the evaluation of proposals more systematic, better documented and more consistent, so that the political processes can more effectively address their responsibilities. Many of the issues associated with proposed regulation changes are complex and emotionally charged. Working through the value conflicts associated with the weighting of criteria can be difficult even when evaluation with individual criteria is straightforward. As complexity and uncertainty increase, the political process often becomes more unwieldy and outcomes of decisions are less predictable. Although wildlife managers are often part of this political process, they also represent wildlife-related sciences and thus are in the best position to offer guidance and structure to make the combined process of scientific and political decision making the most effective.

Review of Attributes and Criteria for Evaluating Regulation Proposals

We address the first of the four basic processes by reviewing several efforts to identify the attributes for which criteria could be set, including criteria we propose. The tasks of adopting appropriate criteria, defining acceptable criterion levels for each, evaluating proposals with available scientific information and applying weights to each of the criteria in a final decision process remain the realm of decision makers in each agency.

Several authors discussed regulation attributes for establishing criteria. Their suggestions are reviewed here for agencies to consider. Although we believe achieving standardization is important for the wildlife management community, we recognize that each state must go through an extremely important process of considering and adopting a set of criteria that meet their specific needs.

Giles (1974) identified nine criteria or actions that he believed would help produce good wildlife regulations. He suggested:

- The regulation must be needed for the long-term benefit of the public.
- Intent of the regulation must be explicit, and its enforcement will effect a recognizable change.
- Enforcement costs should not exceed estimated net social good.
- The regulation shouldnot produce unexpected "counterintuitive" results.
- The existence of the species populations above minimum thresholds must be ensured.
- While ensuring minimum population thresholds, public opportunity should be maximized and annual variance of opportunity should be minimized.
- Changes in regulations should minimize affect on stability and minimize undesirable disruptions for the user and the agency.
- A change in the regulation should result in positive change for the resource "or" the user.
- Regulations should minimally impose moral codes or philosophical preferences of small, public segments on resource users.

While evaluating bowhunting regulations among midwestern states,

Beattie (1983) concluded that good regulations come about through consideration of:

- impacts on user group and landowners;
- human safety for the hunter and nonparticipants;
- impacts on the target resource population;
- changes to hunting tool effectiveness and effect on user group defining characteristics;
- effects from mutual application on public and private lands;
- effects on hunter satisfaction;
- predicted hunter compliance;
- impact on agency credibility by all user groups and landowners; and
- impact on hunter opportunity.

Farmes (1983) suggested additional attributes and criteria he believed to be important:

- maintain quality of the sport, i.e., traditions, hunter density and fair chase;
- public perception;
- social, political and economic considerations;
- "humaneness" in terms of standards for a "natural death" by wildlife; enforceability of the regulation;

- easily understood by users; and
- fair allocation to all users (includes nonconsumptive users).

In their review of regulation-setting processes of state wildlife agencies, Bull and Peyton (2000) posed the following questions:

- Will the regulation impact existing or other proposed regulations?
- Will the regulation adversely affect nontarget species?

Many of these attributes and criteria are intertwined and the lists reflect differing contexts. We suggest a reorganization of the preceding into eight basic criteria for consideration by states evaluating regulation changes. We adapted this list from one initially developed by a committee of 11 wildlife management professionals representing state and federal resource agencies and universities.

We express criteria in a question format to guide deliberation. We acknowledge that they would not technically reflect criteria until some criterion level of performance has been established. An example criterion might read: The regulation will not significantly harm non-target species. The phrase "will not significantly harm" becomes the required level of performance (i.e., criterion level). We also argue that professional wildlifers should strive to influence the development of these standard criterion levels where practical.

Basic Criteria

Need

Is the need clearly defined? Does it address a real or perceived problem? Will the regulation correct the problem if enacted and enforced? Can education replace the need for a regulation?

Consider a proposal for minimum bow draw weight for deer hunting. Minimum bow draw weight regulations, present in most states, are intended to ensure use of effective equipment. However, Missouri, a state with essentially no minimum weight standard, has not reported a problem of abuse of that liberty nor a significant impact to the resource which raises the question of the need for such regulations (L. Hansen personal communication:). Selection of shotgun shot sizes or center-fire rifle caliber is commonly given to the firearm hunter, yet bow weight restrictions imply that bowhunters lack similar judgement on arrow energy requirements for effective harvesting of game. Evaluation under this criterion may call to question the need for such a regulation.

Wildlife Population and Biological Impacts

Would this regulation contribute to or interfere with desired population management goals or objectives? How would this regulation impact target and nontarget wildlife populations or their biological processes? Will the impacts on wildlife populations by this regulation likely to be measurable?

Many regulations, such as arrow weight, broadhead design and others, are intended to reduce wounding loss. Although such regulations may have merit for other criteria, wounding loss does not appear to have a biological impact on some wildlife populations. Again in Missouri where there are currently no restrictions on arrow weight, recent estimates based on a 7-year study of more than 650 radio-tagged white-tailed deer (*Odocoileus virginianus*) suggest that annual bowhunting wounding loss to the deer population is 0.5 percent (L. Hansen personal communication:). A proposal to regulate arrow weight for white-tailed deer hunting would not be supported by this criterion.

Safety

What are the risks to human life or property affected by the regulation? How would this regulation affect injury rates to humans, hunters and nonparticipants? Would it change levels of accidental property damage? Will the risk to life or property be within current levels of public tolerance, or will unacceptable risk be introduced? Will risk reduction by this regulation be detectable at a significant level?

Based on accident and fatality rates associated with bowhunting and other outdoor activities, bowhunting is relatively safe for both participants and nonhunters. Annual accidental fatalities from bowhunting seldom exceed one death nationwide (Hunter Education Association 1994). Improving that safety record could be difficult.

Evaluating a regulation, for example, which intends to minimize the bowhunter's exposure, through handling, to sharpened broadheads would be problematic. Whereas, a proposal which extended hunting hours beyond acceptable shooting light would easily register as a safety issue needing serious consideration

Bull and Peyton (2000) point out that some resource jurisdictions did not have authority to address issues of public safety. However, agencies might also be considered negligent if, during evaluation of regulations, safety of hunters and nonparticipants was overlooked.

Allocation

Does this regulation result in a change in allocation of harvest and/or opportunity? Within limitations of legislation, is the allocation proportional to the demand by user groups?

Changes in allocation are always difficult to address without an evaluation of the user composition. A proposal could change the proportion of hunting opportunity or the harvest allocated within a group such as bowhunters or between hunting segments such as firearm and archery hunters. In some districts, overriding legislation controls allocation.

In Alaska, an archery-only moose (*Alces alces*) hunt that preceded the general firearm season was adopted because an early season was believed to meet the fair allocation criterion. Lower visibility of moose due to vegetation, a lower level of activity by moose, and the prevalence of annoying insects caused lower hunter success and lower participation at that time of year. Thus, an early moose hunt for bowhunters was not expected to significantly reallocate the number of moose harvested disproportionately to the composition of Alaskan hunters.

Compliance (Enforceability)

Is the regulation easily understood by the user and is it practical in its enforceability in the field? Is it easy for the user to comply? Will it effect a major change in equipment or a large purchase by the hunter? Does the regulation cost the agency lost user support and trust?

In an attempt to arrive at minimally efficient archery tackle for harvesting game, some states adopted the requirement that a bow be capable of casting an arrow weighing "X" grains a minimum horizontal distance — generally between 125 and 175 yards (Mayer et al. 2000). Aside from the complexity of this regulation, enforcement is generally impractical in the field because it requires that there be flat terrain, no wind and an adequate area to measure 125 to 175 yards. The fact that bows are not sold with these specifications also makes it difficult for the user to comply with this type of regulation. This type of regulation appears to fail the "easily enforceable" criterion. In addition, stakeholders may label the regulation as ineffective, which reflects poorly on the agency.

Harvest Efficiency (Lethality)

Does this regulation produce an acceptable rate of retrieved game? Will this regulation_measurably change the rate of retrieval? Is the period between shot and death acceptable?

This criterion is increasingly applied and among the most difficult to evaluate. Commonly, the issue is whether bowhunting equipment can cause or improve upon a quick and "humane" death while allowing or requiring the equipment to remain primitive in nature. Scientifically based lethality recommendations for "primitive" equipment are lacking due to the great range of variables involved and the sensitivity to testing equipment on live animals. The application of this criterion will likely remain largely anecdotal in nature until more data become available for a range of hunting methods. "Expert" opinion is commonly solicited from the stakeholder community in the absence of data.

Such was the case recently in Alaska. When lacking scientifically gathered data, the Alaska Board of Game relied on the cumulative experience of long-time Alaskan bowhunters. The state's largest bowhunter group prescribed a minimum bow weight and broadhead types for two different categories of big game—small-bodied, thin-skinned and large-bodied, thick-skinned or heavy-haired. Given the lack of scientific information, the board decided to pass the regulation indicating they placed a higher priority on the risks associated with this criterion (unretrieved game) than the restriction of opportunity associated with the next criterion.

Adequately measuring changes in retrieval rates can be difficult and expensive. But when establishing acceptable retrieval rates, levels that are comparable for all hunting methods should be considered to avoid biases.

Public Perception and Reaction

Do human dimensions data show the regulation is understood and accepted by the appropriate stakeholders? Is stakeholder response based on an understanding of facts? Does the public agree it is necessary? Do stakeholders perceive this change as reasonable and fair?

Perhaps no criterion creates a greater task of assigning relative importance to the full set of criteria than this one. Human dimensions data to provide a clear and representative understanding of stakeholder views have not been routinely collected. Stakeholder preferences are more often assessed through public meetings or other sessions, which makes response difficult to quantify and analyze. Political activity often takes precedent over representative input in these settings. Decision makers must decide what importance to place on each stakeholder group as well as assign the importance of public perception relative to other criteria.

In South Dakota, a proposal was made by an organization of bowhunters to establish a minimum draw weight for archery tackle used to hunt elk. The agency's intention to pass the regulation was halted by a strong opposition from bowhunters who perceived the minimum draw weight would unnecessarily restrict youth and women from participating in the archery elk season. (D. Hanson personal communication: 1999).

In another example, baiting for deer has become a highly contentious issue in Michigan. The Natural Resource Commission (NRC) held a series of public meetings and asked participants to complete a survey indicating whether they believed the NRC should ban the practice, restrict it or not change it. A strong majority (60 percent) of attendees wanted the NRC to take no action on baiting, 18 percent wanted to regulate but not ban baiting and 20 percent wanted baiting banned. The commission tabled a proposal to restrict it. However, a survey of a randomly drawn sample of hunters conducted the same year revealed that although there was slightly more support (28 percent) for banning the practice, 44 percent of those respondents wanted baiting to be restricted in some manner and only 26 percent wanted baiting regulations left as they were. The 71 percent response rate (2,362 respondents) and random selection of participants suggests a more representative input than that provided by the public meetings. Both cases illustrate the importance of basing the evaluation of this criterion on representative and reliable human dimensions data.

Collection of human dimensions data is an essential mechanism for assessing public perception of a proposed change. Human dimensions data can measure the demand for the regulation as well as expectations. The strength of human dimensions data can easily provide the pivotal criterion for decision makers.

Bull and Peyton (2000) indicate that some state agencies questioned the absence of an "ethics and fair chase" criterion among the list of criteria they were asked to consider. We contend that the essence of ethics and fair chase is measured in the public perception and reaction criterion.

Administrative Burden

Can the agency afford to enforce this regulation at the level required to cause a change in hunter behavior? What are the agency's costs? Does enforcement of the regulation pass a cost/benefit analysis?

Items normally considered by the agency as potential burdens include but are not limited to: (1) equipment and operational cost; (2) personnel time; (3) needed changes in priorities; (4) practicality of evaluating; and (5) affect on agency policy.

A proposal recently adopted in Alaska requires that bowhunters be restricted from using a mechanical broadhead for certain large bodied or thick skinned big-game animals. The intended benefit of this regulation was to reduce the risk of wounding game with untested bowhunting technologies. The agency determined that this restriction would require no additional cost to the agency in time or funds because it was assumed that equipment would be checked in the field as part of routine hunter checks. Enforcement agents saw no need to reprioritize their activities in the process of checking hunters nor was there a need to change agency policy. While there would be inherent difficulty in evaluating whether this regulation was a necessary one and produced the expected benefits, any negative effects were expected to be insignificant. The regulation passed this criterion.

Applying Criteria in a Standard Process

These eight basic criteria are intended to emphasize the importance of systematically evaluating regulation options and, as such, serve best as guidelines for an agency's consideration. Whatever criteria are adopted by an agency, they must be applied in a systematic process so that it can be documented and clearly communicated. The criteria could be applied as filters, in which case the proposal must pass each criterion in order to be accepted. Alternatively, the process could be accumulative in which the agency recognizes that the decision must take into account the entire range of criteria.

We describe a filter and a weighted-criteria process as two alternative models. These models are intended as a conceptual guide rather than an attempt to quantify the decision-making process.

Filter Model

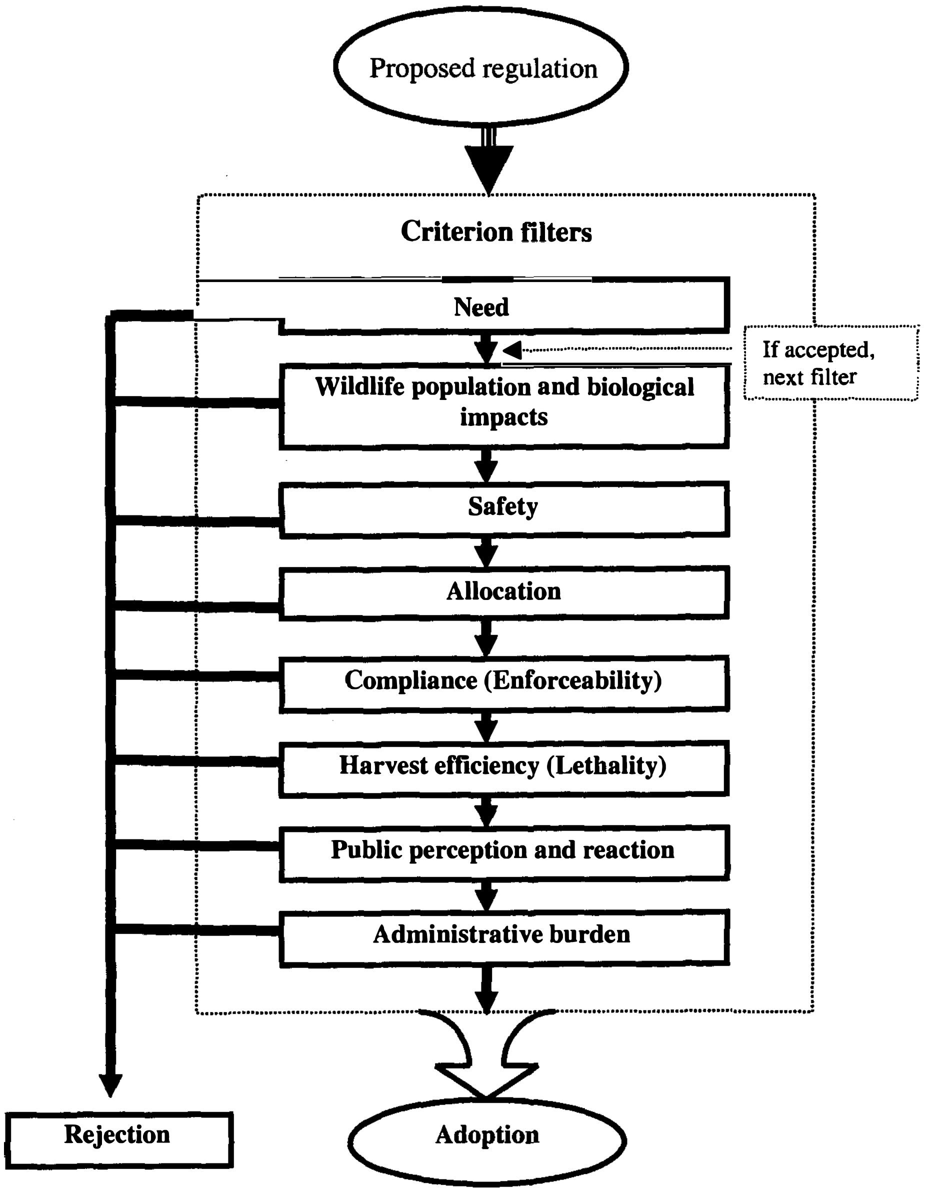
The filter model (Figure 1) lends proposal rejection strength to an individual criterion or "filter." In this conceptual model, a proposal would be evaluated sequentially against criterion filters. The sequence of priorities among the filters could easily vary by state. Qualifications for acceptance and rejection would need to be decided prior to evaluation. Favorable criterion evaluations for all filters would facilitate regulation adoption.

A filter model offers the potential to eliminate a proposal early, thus avoiding expenditure of restricted public funds. Alternatively, this model may terminate an evaluation prematurely and prevent a consideration of relative importance and evaluation of a full range of criteria. Some strong reason for adopting a change may be missed completely. In many cases, this type of model also is unrealistic because sufficient information would not be available to make a definitive conclusion on every filter. In these instances, a weighted-criteria model may be more appropriate.

Weighted-criteria Model

The weighted-score model (Figure 2) requires a complete evaluation of the proposal with all relevant criteria. An agency applying the model would have to consider the state of the science (information) available to evaluate each criterion as ranging from conclusive to expert opinion — or perhaps non-expert opinion. This model causes the agency to consider explicitly and assign the relative importance of each criterion used in the evaluation. In this approach, the quality, quantity and implications of available data must be integrated with the importance of the criterion relative to all others. In the model, integration is achieved by multiplying a "data score" by some agreed upon crite-

Figure 1. Conceptual filter model recommended for state agencies evaluating proposed regulatory changes.



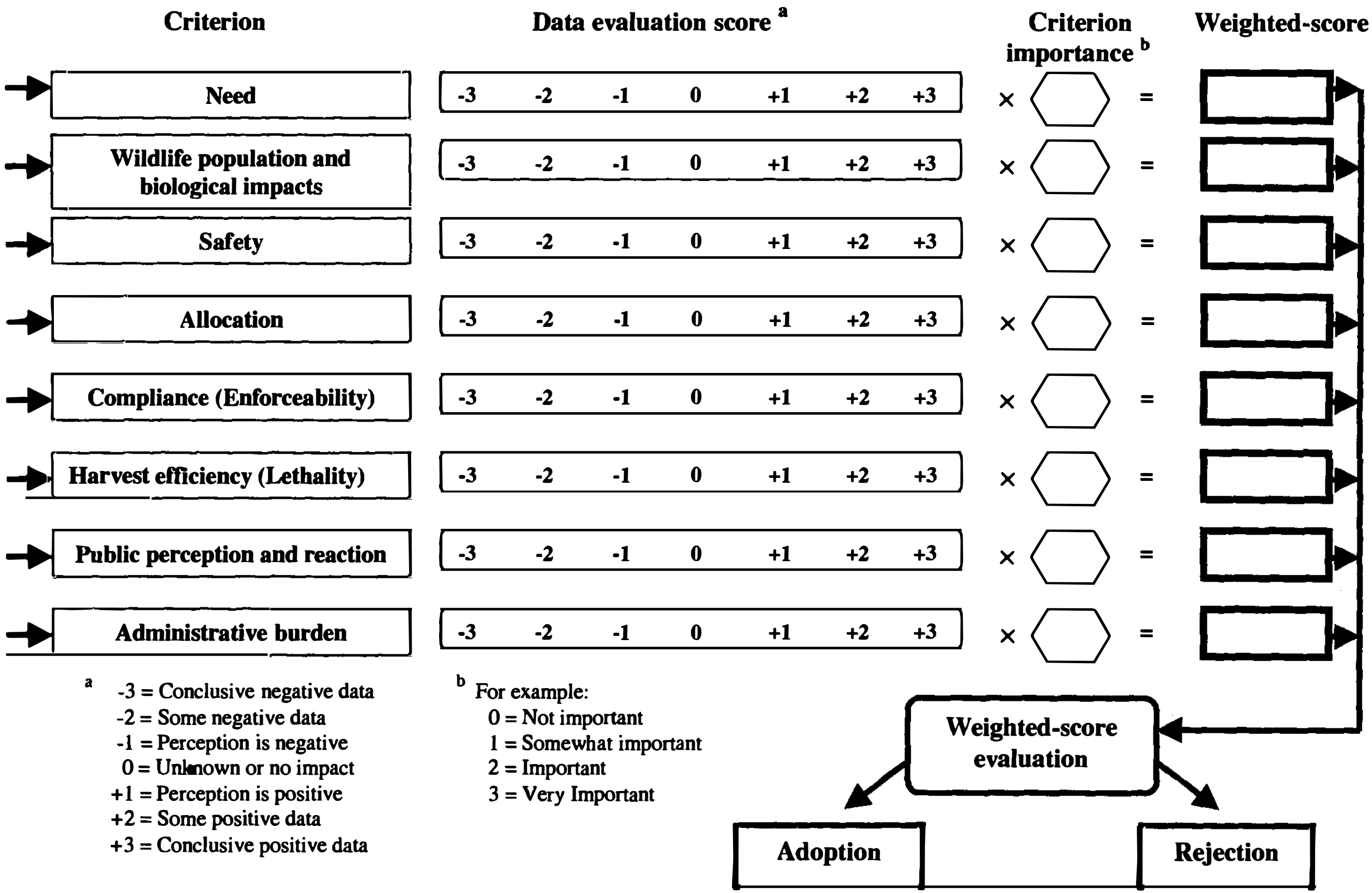


Figure 2. Conceptual weighted-criteria model recommended for state agencies evaluating proposed regulatory changes.

rion importance value. The effect of this type of process would allow a low score, even failure perhaps for a criterion, to be overcome by high scores in other more important criteria. Most importantly, using this model requires the agency to explicitly consider the quality of the information being used (and the uncertainty involved) and to deliberate the weights to be given to each of these criteria assessments. Of course, the agency could decide that any one of the criteria would act as a filter and prevent the proposed change. Again the agency determination of what is most important and what would carry the greatest weight would likely vary among states and possibly among regulation topics (Bull and Peyton 2000).

Conceptually, the use of such a model assures that all criteria will be considered, and it allows for agreement on the status of available information and its meaning. Use of this type of systematic model does not remove the difficult chore of making management decisions under uncertainty nor of establishing priorities among criteria. However, when the decision making passes into the political arena for consideration of relative importance the dialogue should be based on a more comprehensive and clearer consideration of the issues.

Conclusion

While we provided mostly bowhunting examples in this paper, the criteria (with slight modification) and processes are proposed for any method of take regulation, including hunting, trapping and fishing. Evaluation of criteria will only be as valid as the available database. This process helps to avoid unnecessary regulations and clarifies reasoning for support of those adopted. That clarification of support lends accountability for the agency decision, which can be shared with stakeholders and with other state agencies addressing similar proposals.

Wildlife management is a science-based profession, and most professionals attempt to base their management decisions on the available science. For some states, such as Michigan, there is a legal mandate established by a 1996 ballot initiative for basing management on available science. However, it would be naive to presume that politics can be removed from regulation-setting processes and, indeed, political activity of stakeholders and their representatives have a legitimate role in determining the relative weight that any criterion should be given in the final consideration. Scientific data can be used to evaluate a criterion, but not set priorities. The systematic use of criteria could help direct both the scientific and political phases and result in decisions in the best interest of both the resource and the public. When a systematic, rigorous and well-documented evaluation is presented to decision makers, they are more likely to achieve the optimum balance of criteria in their decision.

An organized stepwise process ensures completeness of the evaluation thus minimizing litigation potential, as well as providing future decision makers with a record of past decision processes to use in evaluating future actions.

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The Political Realities of Regulation Setting

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Is scientific wildlife management *a part* of the political system of government or *apart* from all politics, regardless of jurisdiction? Since the birth of the profession of wildlife management, many practitioners in the field harbor the notion that scientific wildlife management is an objective and rational approach to managing wildlife, based solely on data and unfettered by opinion and bias. When the so-called facts about scientific wildlife management have been questioned, ignored or tinkered with by decision makers, practitioners in the field often consider the resulting outcome an indictment of the political system.

No single issue in the evolution of wildlife policy and programs has epitomized this situation more than deer management. In 1946, after a rancorous meeting of the Wisconsin Conservation Commission, Gordon MacQuarrie summed up his view of the treatment Aldo Leopold received by the sporting press and hunters, "This was a man (Leopold), perhaps the greatest of his time in his field, who was also a hunter, an angler and an owner of good hunting dogs. Yet, there were assorted ignorami in Wisconsin who claimed a more profound knowledge of the outdoors than Leopold, and, ridiculous as they seemed then and now, called Leopold a 'bird watcher,' and paid him no heed. . ." (McCabe 1987).

More than 50 years later, Woolf and Roseberry (1998) reviewed a 1997 Pennsylvania deer controversy where sportsmen and legislators forced major changes in the state's scientifically based deer management program. These authors reported actions were being taken to "ease hunter concerns and the political pressure." The divergence from management program recommendations made by wildlife professionals was termed a result of adjusting to the "real world" such as the political relationship between elected officials and their constituents.

Clearly, the wildlife profession never has welcomed input from politicians or sportsmen with differing views into the world of wildlife management, and managers often feel the process has been less-scientific as a result. On occasion, wildlife professionals seem indignant that sportsmen question their judgment, as witnessed by the Leopold incident described earlier where that fact the Leopold hunted, fished and owned hunting dogs was considered reason enough to pay heed to his input. An unfortunate outcome of the gap between the profession of wildlife management and those in society interested in the outdoors has been animosity and distrust on both sides.

The list of those who, on occasion, have been at odds with wildlife managers have included farmers, foresters, all kinds and types of hunters and anglers, animal activists, suburbanites, environmentalists, conservationists, the outdoor media, politicians at all levels, etc. Typically, the source of disagreement can be found in the perceptions of each group about the status of wildlife populations, the impact of wildlife and/or the management regulations used in implementing programs.

In this paper, we review the basic tenets of democratic political systems to reaffirm the fundamental and deliberative role of the legislative branch of government in wildlife policy and programs at all levels. We also assert that the process of creating and refining wildlife laws and regulations has been relatively unstructured and thus the quality and utility of various sources of information -- including scientific data and expert opinion -- has been difficult to discern and sometimes limited in value due to the political and adversarial stances of all parties. We endorse the implementation of stepwise, structured processes for the evaluation of regulations and laws that clearly establish the quality and quantity of scientific and expert knowledge about a particular regulatory proposal.

The Role of the Legislature in Wildlife Management

We operate within a system where legislative bodies representing the people make the laws, executive branch agencies implement and regulate government activities authorized by law and the judicial branch ensures the people are served within the limits of the constitution. Our political system of checks and balances demands that a legislative body of elected representatives provide a forum for creating and refining laws and regulations and for providing oversight of the executive branch agencies.

Since colonial America, wildlife have belonged to all the people and, as community property, have been managed by actions emanating from state and federal legislative bodies composed of the people's representatives (Lund 1980). The fact that wildlife law and regulation has been clearly the province of the people via their elected representatives reflects the many ways in which wildlife impacts the public. Today we refer to the diversity of impacted or interested parties as stakeholders, however, they, in fact, continue to be farmers, ranchers, foresters, many assorted landowners, hunters, anglers, trappers, wildlife viewers, mining interests, energy companies, resort operators, sporting goods companies, conservation, environmental and wildlife advocacy groups and many more. Our wildlife policies have embraced nearly every aspect of life in North America -- economics, esthetics, ethics, interstate commerce, sport, privacy issues, the environment, etc. The list of those interested in wildlife has always been long and diverse. Thus, regardless of whether remedies are sought at the federal, state, county, or city level, a legislative body of elected representatives of the people has been and will continue to be the best arena in which wildlife policy and programs can be debated, developed and evaluated.

The list of conservationists who have made significant contributions while working in a legislative body is impressive. Many in the U.S. Congress have their names attached to discussions about wildlife program budgets -- Pittman-Robertson, Dingell-Johnson, and Wallop-Breaux, for example. In many states, key conservation, wildlife protection and natural resource funding measures have been credited to the perseverance and vision of one or several legislators who were able to lead a majority of their colleagues in safeguarding the state's wildlife populations, habitats and sporting culture.

A second role of legislative bodies is to provide oversight of the agencies entrusted with implementing wildlife law and regulations. Because wildlife management programs have always been a governmental function undertaken to achieve the public good, nearly all wildlife agencies operate within the political system as part of the executive branch of government. The active oversight and participation of the legislative branch of government in the affairs of the executive branch are the norm. Oversight is a natural extension of lawmaking in that the process is an attempt to insure the intent of the legislative branch in enacting a law or regulation is not lost or confused. To ensure the intent of lawmakers is carried out, regulations and rules are developed from the statute language that express the expected outcomes from implementation.

Although there are no substitutes for the legislative process, we acknowledge the efforts of many wildlife agencies to proactively incorporate stakeholders into the management process (Decker and Chase 1997, McAninch and Parker 1991). Accommodating diverse interests in forming management programs and using stakeholder input to adapt ongoing management efforts will diffuse some conflicts and has the potentially reduce the impact of problems for the majority of citizens. Yet, these approaches will be limited by the willingness of people to compromise. Ultimately, when interest groups determine that their point of view deserves greater attention, remedies will be sought in the legislative arena or the courts.

The Process of Making Laws and Regulations

Law making is, at best, a slow, ponderous process. Proposed laws and regulations are received from agencies, advocacy groups of all kinds, and individuals, and are discussed at length informally, with legislators, and formally, in subcommittee(s), committee(s), on the floor, and, often, in conferences between both legislative houses. This is in addition to discussions that commonly occur between and among individual legislators.

Unfortunately, analysis and opinion is available from nearly everyone involved in the process. Legislators are continuously presented with thorough reviews of various aspects of wildlife populations and programs. In materials provided by constituent groups, the rational behind the conclusions is often straightforward and usually calls for directed action. Wildlife professionals, on the other hand, typically submit voluminous amounts of highly technical information that usually offer very cautious, studied actions. The notion that citizens would advocate directly "fixing" features of programs that are deemed detrimental to a particular group is to be expected as is the expectation that the governmental wildlife agency will act carefully to preserve and protect the wildlife resources and programs that have been serving the people.

Throughout this process what is considered to be scientific data and expert opinion often becomes blurred with casual observation, speculation and general opinion. Every interested party has a viewpoint and most will have volumes of information to fortify their position. In many cases, data and expert observations from wildlife scientists will be assembled and used by several participants as a basis for their position. In many situations, data and observations of the general public will be presented alongside the scientific data and interpretation. Unfortunately, for legislators striving to separate fact from fiction, decision-making can become a guessing game based more on credibility of the source than on the evidence.

Much of the acrimony over the outcome of the legislative process is concern about the influence of information on decision makers. Although wildlife agencies are usually the source for all scientific data and the majority of expert opinion on any given subject, low credibility of agency inputs among some constituents and legislators has reduced the impact of wildlife professionals on the final outcomes of the process. This situation can, in part, result in dramatic differences between and among states and provinces in wildlife management regulations such as those governing bowhunting (Mayer et al. 2000).

The position of legislators in trying to determine which information and opinions are most credible has often been made more difficult by years of antagonism among hunters, anglers, trappers and the wildlife professionals in the agencies. Regarding the relationship between one stakeholder group, hunters and the wildlife profession, Woolf and Roseberry (1998) offered that "hunters remain the single most important stakeholder group routinely seeking to exert political pressure on their state's deer program, and many remain skeptical of scientific data and the professionalism and ability of agency staff."

The credibility dilemma is exacerbated when any member of the wildlife profession enhances fundamentally sound information with recommendations based on casual observations and speculation. Far too often, professionals realize the body of scientific data will never extend to all circumstances, and thus, professionals can feel forced to develop stronger arguments than are possible based on the evidence. We would hasten to add that the pressure to provide answers or persuasive arguments to support or refute proposed regulatory changes could often be great -- executive branch agencies do have a role in the political process. Yet, the greatest value of wildlife professionals in wildlife management can be lost in the process.

To complicate matters further, discussions between agencies and wildlife professionals about regulatory changes may not clearly differentiate what is known from scientific inference from assertions based on much less substantiated information. When even wildlife professionals freely blur the quality of information used to make recommendations, it should come as no surprise that legislators have difficulty deciphering the degree to which information is sound and/or biased. Clearly, the occasions where agency professionals have strayed from their scientific roots and laced their recommendations with their biases as hunters, have served to add more fuel to the historic fires. In other words, we would argue that wildlife professionals can be their own worst enemy by not clearly differentiating what they know from scientific data and expert observation from their opinions formed as hunters, anglers, sportsmen, conservationists, or environmentalists.

While we have underscored the essential role of science in legislative deliberations, we caution those who believe there should be a body of scientific data available for use in resolving every wildlife conflict. Clearly, there are limits to the funds available to produce the data many feel are necessary to manage the multitude of wildlife species for which some type of agency action is expected. In reviewing the Mexican Spotted Owl controversy, White et al. (1999) suggested, "American society must clearly define at what level and at what costs they are willing to conserve our natural resources."

We would agree that the complexity of wildlife management challenges confronting our society are daunting. A single urban community can face an ongoing need for population data on deer, waterfowl, rodents, blackbirds, several disease carrying furbearers, insects involved in disease transmission and, perhaps, one or more state or federal threatened or endangered species. Population monitoring procedures for deer for a moderate-sized city or park that would provide the precision and accuracy recommended by many wildlife scientists, would cost tens of thousands of dollars annually. Unfortunately, population monitoring data represent only a portion of the information needed to manage deer and thus, substantial additional annual investments would be needed.

We would suggest that wildlife professionals can provide substantial wildlife management assistance by evaluating existing scientific data and supplying their expert opinions. Legislators are faced with routinely making decisions using the best available scientific data for every other topic of concern to citizens. When a high value is placed on a particular wildlife issue, legislators often respond by dedicating the public resources necessary to acquire additional scientific data. Unfortunately, government funds are sought to support all aspects of our societal needs and wildlife management often does not rate higher than many human health and welfare concerns.

Recommendations for Rule-making Processes

The quality of wildlife laws and regulations would be vastly improved if formal, sequential input processes were used in the evaluation process. Decision makers would welcome assistance in drawing a distinction between facts and expert opinion and the information provided by those advocating a particular position. In addition, since legislative bodies must deliberate on many proposed wildlife policy and management program proposals, wildlife agencies and legislative committees should share in the determination of what scientific information and expert opinion has to offer about a proposed law or regulation.

We endorse the organized stepwise process proposed by Griese et al. (2000), as a mechanism to evaluate proposed wildlife management legislation and regulations. We believe such a process will allow decision makers as well as interested citizens to adequately assess the quality and quantity of available scientific information as it relates to many aspects of a proposed law or regulation. Establishing the degree of certainty about wildlife population and biological impacts, safety considerations, resource allocation and distribution issues, prospects for compliance and enforceability, management efficiency and effectiveness, public perceptions and reactions and the administrative demands of implementation and maintenance in a methodical manner will be a valuable precursor to informed debate and discussion.

The key to this process, as we see it, will be the extent to which scientific information is not only available but can be assembled in a manner that provides direct input to the questions at hand. We understand and accept that scientific data are limited both because the intended application of the results typically goes beyond the scope of the available studies and/or, because these studies are unable to account for all of the multitude of ecological, biological, economic, and other factors considered to be of importance in the debate.

Frankly, scientific information, in and of itself, will never be able to directly provide the answers to complex questions that confront society as wildlife policy and programs attempt to accomplish the public good. The unfortunate truth is that science can only provide guideposts and experts can only offer insight. Knowing precisely the limits of our knowledge is not a weakness of scientific wildlife management but, rather, is a strength upon which to build.

Throughout the long history of American wildlife law and regulation, legislative bodies have always been the place where differences among and between the people were settled and where trends that were destructive to wildlife have been reversed. Although the American system is imperfect and has allowed latitude that at times has threatened some aspects of our wildlife resources, the results of our system are hard to refute -- sound economies, strong wildlife protection and a rich heritage of wildlife appreciation and conservation.

Finally, we would be naive to suggest that the executive and legislative branches of government would work together seamlessly in the development of wildlife laws and regulations. Both bodies are parts of a political system that involves people who have value judgments about the implications of laws and regulations. The stakes are high when the outcomes will impact many facets of society as well as the daily lives of many citizens. Nonetheless, we should be able to assume our roles and offer to honor an agreement to jointly assess the current status of scientific knowledge on a subject before we engage in a debate. Not only would we more clearly understand the point at which we find our views differ, but we could work toward solutions with the confidence that our system of checks and balances, while far from perfect, has created and sustained the greatest conservation movement the world has ever seen.

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Session Two.
Central Forests: A Sleeping Giant

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Current Conditions and Trends in Composition and Structure of Midwestern Forests

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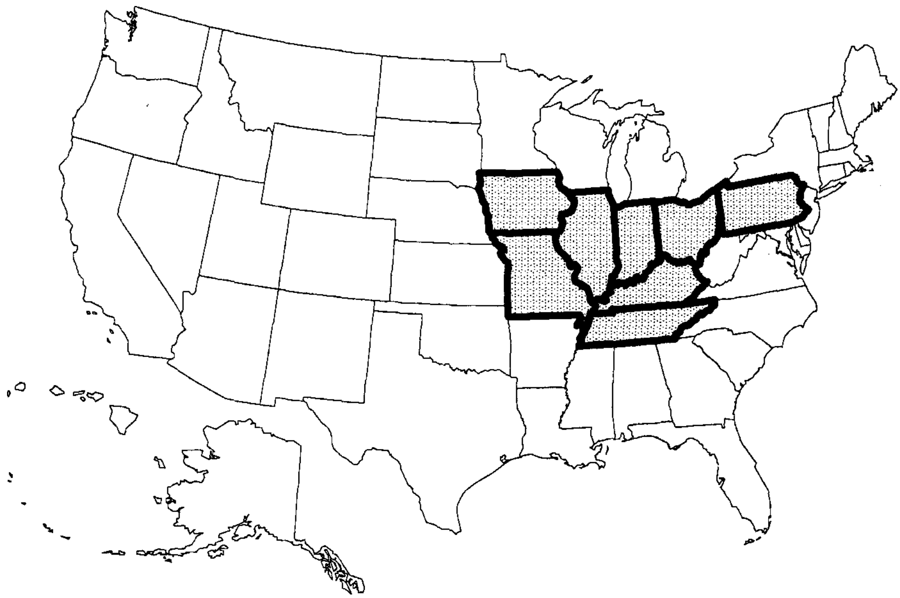
The Midwest is defined in this study as the region including Illinois, Indiana, Iowa, Kentucky, Missouri, Ohio, Pennsylvania and Tennessee (Figure 1). This region encompasses the vast majority of what is commonly referred to as the central hardwood region.

The Midwest region, well known for its high quality hardwood resource, has a wide variety of forest resources that make significant environmental and economic contributions. These forest resources play an important role with impacts ranging from employment and other value-added economic contributions to improving and protecting soil and water resources to providing wildlife habitat.

Midwestern forests are constantly undergoing change due to both natural processes and human impacts. As these changes progress, concerns related to forest fragmentation, species composition, ownership and their management objectives, and future conditions are being raised. Area of forest land in the

Figure 1. Midwest central hardwood study area.



Midwest has been slightly increasing; however, sites where expansion is occurring often are different from where forests have been lost. As a consequence, the potential for these sites to produce benefits could be different from what has historically been produced.

With the control of wildfires, forests are maturing. Species composition is changing from having a number of shade-intolerant species toward being dominated by more shade-tolerant species. Changes in land ownership, management patterns, and harvesting techniques have crucial impacts on the composition and structure of Midwest forests. These changes dictate the quality and quantity of the habitat and resulting impacts on wildlife, thus it is important to document changes in the Midwest USA forest resource.

Methodology

Data presented are from the USDA Forest Service's Forest Inventory and Analysis' (FIA) Eastwide database and are based on the most recent statewide forest inventory for each state (Hansen et al. 1992). Data presented pertain only to timberland, however, more than 95 percent of the forest land in the Midwest is classified as timberland (Powell et al. 1993). Timberland is forest land capable of producing more than 20 cubic feet per acre (1.4 m^3/ha) per year of industrial wood crops under natural conditions and not withdrawn from timber utilization. There are other classifications of land with trees, including reserved forest land, narrow planted and natural wooded strips, and pasture land with trees, that do not meet the timberland definition. These non-timberlands make important contributions to not only wildlife habitat but also to other forest-related benefits. Until recently, FIA did not install field plots on these other lands and, as a result, data are limited for forest land classifications other than timberlands.

For stand-size class, deciduous sawtimber-sized stands are stands with half or more of the total live tree stocking in trees that are at least 11 inches (27.9 cm) in diameter at breast height (dbh). Stand age is the average age of the dominant and co-dominant trees in the stand. Volume is the net volume of trees 5 inches (12.7 cm) dbh and over, from one foot (30 cm) above the ground to a minimum four-inch (10.1 cm) top diameter outside bark or to the point where the central stem breaks into limbs. All live volume is used in this study, which includes non-commercial trees and rough and rotten trees.

Dates of the most recent statewide inventories range from 1985 in Illinois to 1998 in Indiana. Unless noted, only the most recent FIA inventory was used for each state and then summed to regional totals. This regional composite of state inventories with disparate inventory dates has an average inventory date of 1990. Because of the differences in inventory dates and lack of multiple inventory dates in the database for some states, Indiana data are used to make comparisons over time. Indiana was selected due to its general location in the middle of the study region, and because it has the most recent inventory of the states within the study region. Comparisons for Indiana are based on inventories completed in 1986 and 1998.

FIA implements a systematic grid for its estimates. From the grid, plots are selected for determinations of land use through remote sensing. A subset of these plots is selected for field measurement where plot level and individual tree measurements are made. In the study area, 17,868 field plots were measured, with individual measurements taken on 269,020 trees during the most recent inventories.

Results

Area

Within the Midwest region, there are 246.6 million acres (99.8 million ha) of land, 72.6 million acres (29.4 million ha) (30 percent) of which are classified as timberland (Table 1). The majority of the timberland is dominated by deciduous species. Of the total area of timberland, 41 percent is classified as oak/hickory (*Quercus/Carya*), 18 percent as maple/beech-birch (*Acer/Fagus/*

Table 1. Midwest states' area in thousands of acres (ha) of timberland by forest type and stand-size class.

Forest type	Total	Stand-size class: Sawtimber	Poletimber	Sapling/seedling
Conifers	7,631 (3,091)	3,466 (1,404)	2,445 (990)	1,721 (697)
Oak-hickory	29,827 (12,080)	16,475 (6,672)	8,709 (3,527)	4,792 (1,941)
Bottomland hardwoods	6,867 (2,781)	4,123 (1,670)	1,550 (628)	1,006 (407)
Maple-beech-birch	13,026 (5,275)	8,921 (3,613)	3,263 (1,322)	2,252 (912)
Other hardwoods	15,293 (6,194)	7,172 (2,905)	4,330 (1,754)	2,846 (1,152)
Total	72,643 (29,421)	39,662 (16,063)	20,344 (8,239)	12,638 (5,118)

Betula), 11 percent as conifers, 9 percent as bottomland hardwoods, and 21 percent as other forest types. Depending on the site, oak/hickory and maple/beech/birch forest types are considered to be self-replacing with regeneration having similar species composition to their overstory. In addition, these plant communities are replacing early successional forest types such as cottonwood (*Populus deltoides*).

Timberlands in the Midwest are predominantly classified as being on mesic sites. Few timberlands are in the very wet (hydric) or very dry (xeric) physiographic classes. Hydromesic sites, often referred to as bottomlands, represent less than 10 percent of the total area of timberlands in this region.

Bottomland hardwoods are a crucial component for wildlife in the Midwest. In addition to the food source and cover, these forests provide important travel corridors. Due to the highly productive soils associated with bottomland hardwoods this forestland classification has received the most pressure for conversion to agriculture uses. In general, the majority of the bottomland hardwoods that had the potential for conversion to these land uses have been converted. However, current pressures on forest land for conversion to other land uses derive from the demand for additional urban/suburban space, second homes and recreational facilities. These pressures exist for both bottomland and upland hardwoods.

Habitat characteristics change, even if trees remain when timberlands are developed. Natural regeneration is often curtailed; stocking is usually lowered; snags, dead trees and hollow/rotten trees that can provide excellent habitat are often removed (from a safety perspective); and other changes occur with development.

There has been a net increase in the total area of timberland since the late 1970s to early 1980s. The primary causes of this increase were widening of existing narrow wooded strips and the conversion of cropland and pasture to timberland. These increases were greater than losses by development of timberland. For example, Indiana timberland increased from 3.9 million acres (1.6 million ha) in 1967 to 4.2 million acres (1.7 million ha) in 1986 and to 4.3 million acres (1.7 million ha) in 1998.

Land uses change as forests are converted to other uses and other land uses convert to forest. For example, in the 12 years between inventories in Indiana, 382,000 acres (154,600 ha) of timberland were converted to nonforest land uses and 421,000 acres (170,400 ha) of nonforest land converted to timberland. This resulted in the net increase in the total area of timberland in Indiana. However, the new timberland areas occupy different sites than those timberland areas lost to other land uses. It is generally thought that in the Midwest, many of the new timberlands have established on upland mesic sites while many of the timberland losses have occurred on bottomlands.

In addition to the changes in land use, changes occur in lands that remain timberland. Changes in species composition occur as the forest matures; natural disturbances such as wind storms and floods transpire; and human-induced activities such as harvesting, timber stand improvement (TSI), and tree planting happen. These events change the composition of the forest and the resulting forest type classification. As the woody plant species composition changes, the wildlife species that use these plant communities also change.

In the Midwest region, 87 percent of timberlands are privately owned, 84 percent by private and corporate landowners and 3 percent by forest industry. Public ownership is comprised of 7 percent Federal, 6 percent State, and less than 1 percent local ownership for a total of 13 percent publicly owned.

Larger-sized trees dominate the Midwest timberland resource. More than 55 percent is classified as being in the sawtimber-size class (Table 1). Poletimber-sized stands (dominant trees between 5 inches [12.7 cm] and 11 inches [27.9 cm] dbh) account for 28 percent and sapling-seedling-sized stands [dominant trees less than 5 inches (12.7 cm) dbh] account for only 17 percent of the timberland area. Average stand-size class is increasing, an indication of a lack of significant disturbance through either natural occurrences or harvesting. Selective harvesting methods used in hardwood stands throughout the Midwest region do not cause the large-scale disturbances that are needed to move these larger-sized stands to smaller-sized stands. In addition, possible high-grading of hardwood stands tends to leave the "economically less desirable" species and lower quality cull trees, which could hasten the transition to a later seral stage.

Stocking is a measure of how well-occupied the land is by trees. Stocking is an important component as it influences successional processes such as the type of regeneration, individual tree growth habit and forest structure which directly impact wildlife habitat. In the Midwest region, 70 percent of the timberlands are medium to fully stocked and 13 percent are overstocked (Table 2).

Table 2. Midwest states' area in thousands of acres (ha) of timberland by forest type and stocking class.

Forest type	Total		Stocking class: Over		Full/medium		Poor/non	
Conifers	7,631	(3,091)	1,047	(424)	5,627	(2,279)	958	(388)
Oak-hickory	29,827	(12,080)	2,031	(822)	21,705	(8,791)	6,091	(2,467)
Bottomland hardwoods	6,867	(2,781)	862	(349)	4,534	(1,836)	1,470	(595)
Maple-beech-birch	13,026	(5,275)	2,466	(999)	8,488	(3,438)	2,071	(839)
Other hardwoods	15,293	(6,194)	2,960	(1,199)	10,650	(4,313)	1,684	(682)
Total	72,643	(29,421)	9,366	(3,793)	51,004	(20,656)	12,274	4,971

Only 7 percent of the oak/hickory forests were overstocked compared with the 19 percent for both maple/beech/birch and other hardwoods.

Individual tree growth habitat is a reflection of stocking. Open-grown trees, often referred to as "wolf" trees, generally have large well-developed crowns with larger than average branches. For the same species, open-grown trees provide considerably different habitat than trees grown in an overstocked condition. Depending on the habitat requirements and woody plant species, stocking can be one of the most important criteria for determining quality of the habitat.

Another vital aspect of habitat quality is stand age. In FIA inventories, stand age is determined if possible, if not the stand is classified as mixed. Of the stands with an estimated stand age (not classified as mixed), 55 percent are more than 40 years old (Table 3). Only 15 percent of the timberlands in the Midwest have an average stand age of less than 20 years. Young stands provide crucial habitat for many game species such as white-tailed deer (*Odocoileus virginianus*) and ruffed grouse (*Bonasa umbellus*). Many wildlife species rely heavily on the seedlings, shrubs and understory "brush" associated with these younger stands.

Currently, 14 percent of the region's timberlands are estimated to be more than 80 years of age. Mature and overmature forests provide important habitat that is not typically provided by younger stands. Overstory structure, down and

Table 3. Midwest states' area in thousands of acres (ha) of timberland by forest type and stand age class.

Forest type	Average stand age[a]: 1 to 20		21 to 80		80 +	
Conifers	1,113	(451)	3,574	(1,448)	309	(125)
Oak-hickory	2,771	(1,122)	13,928	(5,641)	4,381	(1,774)
Bottomland hardwoods	874	(354)	4,494	(1,820)	522	(211)
Maple-beech-birch	2,010	(814)	9,549	(3,867)	1,148	(465)
Other hardwoods	1,646	(667)	9,386	(3,801)	1,642	(665)
Total	8,347	(3,381)	40,572	(16,432)	8,141	(3,297)

[a]There were 15,584 acres (6,311 ha) of timberland in the mixed stand age class.

dead woody material, snags, and other components enable mature and overmature timberlands to function in a vital manner for selected wildlife species. For example, the pileated woodpecker (*Dryocopus pileatus*) prefers dead limbs of large trees for nesting.

Number and Type of Trees

Species composition is an important aspect of wildlife habitat. Three states, Pennsylvania, Indiana and Missouri, were selected to discuss species composition. In the most recent inventories, a total of 98 different tree species were found on FIA plots in Pennsylvania, 92 in Indiana and 90 in Missouri. While the total number of species was similar, there were considerable differences in the species composition. There were nine tree species found in Missouri that were not found in the other two states. Indiana had 11 tree species that were not found in the other two states. Pennsylvania had 18 tree species that were not found on FIA plots in Indiana or Missouri. Generally, as you move east across the Midwest, climatic changes result in different woody plant species compositions. However, there were 64 species that were found on FIA plots in all three states.

In total, there currently are more than 40 billion trees in the eight state study area (Table 4). Oak species were the most common, representing more than 16 percent of all live trees. The second most common species group was hard maples—sugar (*Acer saccharum*) and black (*Acer nigrum*)—with 10 percent of all live trees. Deciduous species represented 92 percent of all live trees.

Only 2 percent of the total live trees in the Midwest were more than 15 inches (38.1 cm) dbh More than three-fourths of all of the trees were less than 5 inches (12.7 cm) dbh The dominance in total number of trees by smaller-sized trees could lead to the assumption that the timberlands were dominated by sapling/seedling-sized stands. However, as noted, timberlands are predominately

Table 4. Midwest states' number of live trees (in millions) by diameter class.

		Diameter class in inches (cm)				
Species	Total	1.0-4.9 (2.5-12.4)	5.0-8.9 (12.7-22.6)	9.0-14.9 (22.9-37.8)	15.0-18.9 (38.1-48.0)	19.0+ (48.2+)
Conifers	3,274.9	2,219.2	724.3	294.0	27.9	9.5
Oaks	6,677.0	3,725.5	1,483.6	1,095.4	251.3	121.1
Hickories	2,867.8	2,054.2	509.1	259.6	35.4	9.5
Silver/red maple	4,152.7	3,256.8	590.3	248.7	37.8	19.1
Sugar/black maple	2,537.0	2,016.3	320.6	159.4	27.8	12.8
Yellow-poplar	885.7	546.9	156.6	127.2	37.7	17.2
Other hardwoods	20,276.8	17,096.6	2,147.8	831.5	132.6	68.5
All species	40,672.0	30,915.5	5,932.4	3,015.9	550.5	257.7

the size of sawtimber. The reason is that while there might be thousands of seedlings in a stand, if larger trees are present they dominate the stand and the size classification. The growing space needed by a seedling is dramatically different from that needed by a large dominant tree. The crucial point for wildlife is that the combination of overstory and understory woody species, their interspersion and their species composition dictate the forest's structure and function.

The oak species group differed in terms of number of smaller-sized trees. Only 56 percent of all oak trees were less than 5 inches (12.7 cm) dbh In most states, the number of oak seedlings is remaining static at best. Oak seedlings can survive in shade for several years, however seedlings must have adequate sunlight to successfully develop. If the Midwest timberlands continue to mature, future regeneration of oaks could become even more limited. Oaks are of special interest due to their mast production, cover, roosting, and other habitat associated values but also due to their other economic and environmental benefits. For example, acorns are one of the primary plant foods for blue jays (*Cyanocitta cristata*) and eastern gray squirrel (*Sciurus carolinensis*). The future of oak species in the Midwest could have a direct tie to many wildlife species future populations.

There are an estimated 808 million trees in the Midwest that are more than 15 inches (38.1 cm) dbh. Of these, almost 50 percent are oak species. Oaks are long-lived and, once established, not as susceptible to environmental influences such as windthrow and wildfires when compared with other species native to the study area. However, the established oak resource also is threatened from oak wilt (*Ceratocystis fagacearum* [Bretz] Hunt), oak decline and gypsy moth (*Lymantria dispar* L.) (Juzwik and Schmidt in press). If oaks succumb to these factors, short-term wildlife habitat could be improved through tree mortality but long-term wildlife habitat quality could be negatively impacted if the trees are not replaced by similar species.

Volume

This study focuses on all live tree volume because habitat generally does not rely on potential tree quality as selective criteria. In total, there are more than 100.6 billion cubic feet (2.8 billion m^3) of volume on the 72.6 million acres (29.4 million ha) of timberland in the study region (Table 5). This equates to an average of almost 1,400 cubic feet per acre (97 m^3/ha) of timberland across the entire region. To provide a comparison, average volume per acre in Indiana increased from about 680 cubic feet per acre (47 m^3/ha) in 1950 to 1,589 cubic feet per acre (111 m^3/ha) in 1998.

With a high average volume per acre, concerns rise regarding fuel hazards, limited regeneration, crown size and ratios, growth being suppressed due

Table 5. Midwest states' all live volume in million cubic feet (m^3) by diameter class in inches (cm).

			Diameter class					
			5.0-8.9		9.0-14.9		15+	
Species group	Total		(12.7-22.6)		(22.6-37.7)		(37.8+)	
Conifers	8,367	(237)	2,659	(75)	4,114	(116)	1,594	(45)
Oaks	36,689	(1,038)	5,348	(151)	15,361	(435)	15,981	(452)
Hickories	7,694	(218)	1,865	(53)	3,871	(110)	1,959	(55)
Silver/red maple	8,470	(240)	2,205	(62)	3,704	(105)	2,560	(72)
Sugar/black maple	5,656	(160)	1,314	(37)	2,496	(71)	1,846	(52)
Yellow-poplar	6,208	(176)	692	(20)	2,438	(69)	3,077	(87)
Cottonwood/aspen	1,855	(52)	350	(10)	695	(20)	810	(23)
Other hardwoods	25,689	(727)	6,535	(185)	10,761	(305)	8,393	(238)
All species	100,627	(2,848)	20,968	(593)	43,439	(1,229)	36,219	(1,025)

to competition, and other forest health issues. Greater volume levels can have positive or negative impacts on wildlife habitat, depending on the requirements for specific species.

Volume has been increasing over time throughout the region. For example, growing-stock volume in Indiana increased from 5.2 billion cubic feet (147 million m^3) in 1986 to 6.9 billion cubic feet (195 million m^3) in 1998, reflecting the increase in both area and stocking during the 12 years between inventories. Wildlife species such as the brown thrasher (*Toxostoma rufum*) that prefer brushy or thicket-covered uplands could be negatively impacted from greater stocking levels which could decrease understory "thickets" due to lower light levels.

In the Midwest, 41 percent of the total area of timberland is in the oak-hickory forest type and 44 percent of the total live volume is in the oak and hickory species groups. Above average volumes indicate that the timberlands are predominantly stocked by larger-sized trees. As these timberlands continue to mature, it could be expected that future regeneration might favor shade-tolerant species such as maples and beech. As a result, future regeneration of shade intolerant species might be expected to decline.

Change Factors

Primary factors of change in timberlands in the Midwest are growth, mortality and removal. To determine net change, mortality is subtracted from gross growth to obtain net growth. Net growth can be compared to removals to determine a growth-to-removals ratio. A ratio of more than one implies that more growth is occurring than what is being removed. This leads to increases in total volumes, stocking levels, average stand-ages, and other measures of stand sustainability. On average, the eight state study region has a 2.5 to 1 ratio of growth to removals (Table 6), indicating that each year total volume is in-

Table 6. Midwest states' growing-stock growth to removals ratios.

		Diameter class in inches (cm)		
Species group	Total	5.0-8.9 (12.7-22.6)	9.0-14.9 (22.6-37.8)	15.0 + (37.8 +)
Conifers	1.3	2.7	1.3	0.4
Oaks	1.9	4.0	2.0	1.3
Hickories	8.6	14.2	9.5	4.2
Silver/red maple	8.1	31.7	9.8	2.9
Sugar/black maple	2.8	5.0	2.7	1.8
Yellow-poplar	10.5	35.4	16.8	6.5
Other hardwoods	2.3	5.1	2.3	1.3
All species	2.5	5.1	2.6	1.5

creasing at a substantial rate. As would be expected, the larger-sized trees have the lowest growth-to-removals ratios since larger trees have greater economic value from a harvesting perspective and thus are more likely to be harvested.

Conifers, oaks and other hardwoods all have a growth-to-removals ratio of less than 1.3 to 1 in the larger diameter size classes. Yellow-poplar (*Liriodendron tulipifera*), hickories, silver and red maple (*Acer saccharinum, A. rubrum*), all have high growth-to-removals ratios for all diameter classes. This indicates that their role in providing habitat in the future could increase from current levels.

Forest Structure

Two measures of forest structure are crown class distribution and crown ratio. Crown class distribution is a measure of the dominance of the individual tree's crown compared to the overall stand. Throughout the Midwest region, a low percentage of the trees on timberlands are open grown (0.2 percent). This is primarily due to the minimum stocking necessary to qualify as timberland, which excludes most open grown treed lands. Thus, timberlands in the Midwest region provide a relatively small proportion of the habitat for wildlife species that require large "wolf" trees. Nonforest lands with trees provide the majority of this habitat.

Almost 95 percent of all cottonwood trees in the region are considered dominant or codominant trees (Table 7). This shows that most cottonwoods are not regenerating under existing stands (as expected since cottonwood is shade-intolerant). As a comparison, 40 percent of the sugar and black maple trees are considered intermediate or overtopped, representing the understory. In general, timberlands with above average percentages of shade tolerant species have a greater percentage of trees in the understory classifications.

Crown ratio is the percentage of live branches compared to the total tree height. On average, 52 percent of all trees in the Midwest have a crown ratio of 41 to 60 percent (Table 8). As timberlands in this region continue to mature,

Table 7. Midwest states' percentage crown class distribution by species group.

	Crown class				
Species group	Open grown	Dominant	Codominant	Intermediate	Overtopped
Conifers	0.2	14.6	50.3	32.0	2.9
Oaks	0.1	17.3	60.7	20.4	1.4
Hickories	0.2	13.8	52.1	31.4	2.4
Silver/red maple	0.1	9.2	58.4	29.5	2.9
Sugar/black maple	0.1	8.2	51.9	34.0	5.8
Yellow-poplar	0.2	15.7	58.5	24.1	1.5
Cottonwood-aspen	0.3	25.2	69.7	4.2	0.5
Other hardwoods	0.2	11.7	53.0	32.0	3.0
All species	0.2	14.5	55.2	27.8	2.4

crown ratios will continue to increase as shade intolerant species are replaced. The impact on wildlife habitat will be more structure, more potential cover, greater potential roosting areas, and other advantages associated with larger-sized crowns.

Discussion

The Midwest timberland resource is undergoing important changes with repercussions for wildlife. For example, woodcock (*Philohela minor*) numbers have declined by 37 percent since 1968 in the Midwest, primarily due to habitat loss and the maturing of the region's forests (Smith 1999).

The future of the resource lies in the hands of individual private landowners. Their decisions regarding management will dictate the characteristics of the future resource and resulting benefits. The potential exists for an emergence of different objectives for timberland management. Currently, it appears that some landowners are moving from a focus on wood fiber production toward ecosystem management with multiple considerations. A portion of this change in management philosophy is due to the smaller-sized tracts that could

Table 8. Midwest states' percentage crown ratio by species group.

Species group	0 to 20	21 to 40	41 to 60	61 to 80	81 to 100
Conifers	2.2	38.6	48.3	8.4	2.5
Oaks	0.6	35.8	56.5	6.3	0.8
Hickories	0.6	33.6	55.8	8.7	1.3
Silver/red maple	0.9	38.1	51.8	7.5	1.7
Sugar/black maple	1.0	31.5	51.4	12.4	3.8
Yellow-poplar	0.6	38.7	55.8	4.1	0.8
Cottonwood-aspen	4.1	59.7	34.2	1.6	0.4
Other hardwoods	1.5	38.0	49.6	9.0	1.9
All species	1.2	37.7	52.3	7.3	1.5

be formed with forest fragmentation. As the average size of timberland ownership decreases, the potential for management for wood fiber production decreases. This will change the habitat, resulting in advantages for some species and disadvantages for other species.

Overstocked stands are of concern due to their increased potential for pest outbreaks and wildfire. In an overstocked status, growth rates can be lowered, stress can be increased and regeneration can be low due to the increased level of competition. Both over-and under-stocking can be addressed through management but end results of management actions need to be weighed.

A major driving force in the Midwest is the aging of the timberlands. With only 15 percent of the timberlands having an average stand age of less than 20 years, later successional types and their associated species are replacing early successional forest types. As plant species composition changes, wildlife species that habituate these timberlands also change.

One of the reasons for increased stocking and aging of the timberlands is the harvesting techniques used in this region. Almost all harvesting is done through selective means where individual trees are selected for removal. This leaves the majority of the trees to form the residual stand. This harvesting method does not cause disturbance to the degree necessary to enable early successional species such as cottonwoods to regenerate.

Whenever vegetation is manipulated through either natural or human-caused events, habitat quality is altered. The alteration will be positive for some wildlife species and negative for other species. Impacts must be considered prior to implementing the manipulation. Prior to European settlement, wildfires and other natural events provided disturbances that enabled early successional forests to maintain themselves. With control of wildfires, we are allowing succession to progress. As a result, forests are maturing, woody plant species are being replaced and volume and stocking levels are increasing. All of these changes are impacting wildlife habitat. Wildlife species that are enhanced by these changes will gain at the expense of wildlife species that rely on younger-aged forests, lower stocking levels and more-open forests. If this is the desired goal, no major changes in management need to be made. If not, changes in management strategies will need to be considered.

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Sustaining Oak Ecosystems in the Central Hardwood Region: Lessons from the Past—Continuing the History of Disturbance

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Oak savannas, woodlands and forests were dominant ecosystems throughout the central hardwood Region (CHR) before European settlement. Today, only 0.02 percent of the original oak savannas present at the time of European settlement remain, and bottomland hardwood forests have been reduced by 70 to 95 percent depending on the watershed (Nuzzo 1986, Sharitz and Mitsch 1993). This deforestation resulted largely from agriculture development.

Upland oak/hickory forests are still the major (54 million acres) forest type in the CHR. However, current disturbance regimes are driving forest succession to more shade tolerant species such as the maples and pioneer species such as yellow-poplar, especially on the more productive lands (site index = >60 feet, base age = 50) (Lorimer 1993). However, increased competition from shade tolerant trees and shrubs reduces oak regeneration potential even on drier sites. The inability of oak reproduction to compete and recruit into the overstory is the fundamental cause of oak sustainability problems in forested situations.

The primary factor leading to the successional displacement of oak has been a change in the historic disturbance regime that has altered the competitive relationship between oak and its associates. The widespread distribution and dominance of oak is a result of a long history of frequent fire, which peaked shortly after European settlement (Abrams 1992). Fire suppression has nearly eliminated wildfire as a forest disturbance since the 1930s, and the lack of fire is the most often cited cause of the recent oak regeneration problem, especially on high quality sites (Lorimer 1993).

The loss of oak forests in the CHR is a concern to resource managers and private forest landowners. Under current disturbance regimes, it appears that oak dominance will be increasingly confined to the less productive sites without human intervention through management. The more productive sites will succeed to other species, with a possible loss of species diversity, and loss of mast production that is important to so many wildlife species. Sustainability of oak ecosystems is predicated on an understanding of oak ecology and disturbance history, and it requires planned disturbances that favor oak regeneration and development.

Oak Regeneration Ecology

Oaks regenerate as new seedlings, seedling-sprouts and stump sprouts. Shoot growth of new seedlings (i.e., those that have not experienced shoot dieback) is relatively slow for most oak species, and hence, regeneration that relies mainly on new seedlings usually results in failure, even when abundant but small oak seedlings exist before overstory removal (Johnson 1993, Lorimer 1993). Successful oak regeneration is dependent upon there being an adequate number of large advance reproduction (primarily seedling sprouts that are present before overstory removal).

Oaks have evolved a regeneration strategy that relies on building large root carbohydrate reserves, at the expense of shoot growth, and a tremendous ability to produce new sprouts after death of the original shoot. Oaks are better adapted than many of their competitors to disturbances or environmental stresses that cause shoot dieback because they can repeatedly produce new sprouts (i.e., seedling sprouts) from the supply of dormant buds located at the root collar, which is often beneath the soil surface where buds are protected from fire or herbivores. Oak seedling sprouts with large root systems are able to grow rapidly in height after release from the overstory. In contrast, oak seedlings with small root systems are quickly suppressed by large shade tolerant (e.g., maples) saplings and fast growing shade intolerant (e.g., yellow-poplar) reproduction.

Oak reproduction is most competitive on sites with below average productivity that experience frequent disturbances such as fire and environmental stresses such as drought. On these sites and under these conditions, survival and growth of oak competitors are limited, as is overstory density, vertical structure of vegetation, biomass and leaf area. When light at the forest floor is adequate, oak advance reproduction can persist for decades (Merz and Boyce 1956). Oak seedling sprouts can accumulate with each good acorn crop, and grow in the understory of open-structured woodlands. These oak advance reproduction are able to develop large root systems that then can supply the energy for rapid shoot growth upon release from the overstory.

Today, oak forests on mesic sites do not usually regenerate to oak in the absence of disturbances that limit competing vegetation in both the understory and overstory. Without such disturbances, heavy shade (e.g., 1 percent of full sunlight) develops as shade tolerant canopies form in the understory. In this low light, oak advance reproduction does not grow well and does not survive. Abundant oak advance reproduction may result from a single good acorn crop, but large seedlings do not develop in the heavy shade. Those seedlings that do persist are small and have low regeneration potential. Thus, there are frequent and prolonged periods when there is little or no oak advance reproduction. Harvesting during these periods ensures that there will be fewer oak in the future forest.

Accumulation of large oak advance reproduction on mesic sites requires recurrent disturbances, which historically had been the role of fire before European settlement. Fire increases light at the forest floor by decreasing the density and size structure of woody species in the understory and by reducing overstory density. In the absence of periodic fires, mesic sites develop dense overstory canopies and complex vertical structure. Eliminating tall understory woody stems and reducing overstory density increases oak advance reproduction survival and growth (Lorimer et al. 1994, Larsen et al. 1997).

Stump sprouts are stems of reproduction that arise from overstory trees (stems ≥2 inches dbh) cut in a timber harvest, or topkilled by fire. Stump sprouts are the fastest growing form of oak reproduction. When growing in the open, oak stump sprouts have high probabilities of capturing growing space and maintaining dominance in the overstory. This growth advantage is due, in part, to a large root system that can deliver sufficient water, nutrients and other metabolites to the shoot.

The capacity for stump sprouting varies among species, and with tree size, age and vigor. It also depends on the season that the parent stem is cut. Most oak species have high sprouting potential (nearly 100 percent) for stems with diameters in the range from 2 to 8 inches dbh (5 to 20 cm) (Dey et al. 1996). Increasingly larger trees produce fewer sprouts, and oaks larger than 20 inches (51 cm) in dbh sprout infrequently. Sprouting potential and growth also decrease in older trees (Kozlowski et al. 1991). Cutting upland oaks during the dormant winter months results in higher densities of more vigorous sprouts per clump compared to trees cut during the growing season (Wendel 1975, Kays et al. 1985). Although they are the most competitive form of oak reproduction, stump sprouts should not be relied upon alone to sustain oaks in the future stand because the stocking of sprout producing trees is usually not high enough to maintain stand composition, unless the oak forests are young (e.g., < 60 years old) when harvested.

Disturbance History

Native American Fire

For 10,000 to 20,000 years, Indians used fire to influence forest composition and structure and the extent of grasslands in North America (Pyne 1982, Delcourt et al. 1993, Krech 1999). Indian fire favored the widespread dominance of (1) the oak woodlands and forests; (2) the eastern prairies, glades, and barrens; and (3) the oak and pine savannas. Many forests had an open, park-like appearance because of a long history of fires (Lorimer 1993). In the CHR, the cycle of fire determined the balance between tallgrass prairies, oak savannas, and oak woodlands and forests (Gleason 1913).

Frequent fires reduced the density and size of woody species in the understories of oak-dominated forests, increased the diversity in ground flora and favored the growth of grasses, legumes and other herbaceous plants (Wright and Bailey 1982). The overall effect was to promote the accumulation and growth of advance reproduction of the fire-adapted oaks by reducing understory competition and causing occasional overstory mortality, thus increasing light at the forest floor. Oaks often persisted as "grubs" in the understories of forests and savannas, as well as in prairies, glades, and barrens.

Variability in fire-free intervals was substantial, ranging from 1 to 70 years (Cutter and Guyette 1994, Guyette 1995, Guyette et al. 1999). This variability in fire frequency played a critical role in the regeneration and recruitment of species into the overstory because oaks require some fire-free period to develop enough resistance to burning injury before the next fire. During the longer fire-free periods, oak seedling sprouts were able to grow rapidly, increasing their ability to survive subsequent fires.

Low intensity surface fires were most common (e.g., every 5 to 15 years) in hardwood forests before the fire suppression period (Guyette and Dey 1997a, Sutherland 1997). These surface fires usually caused mortality of single or small groups of mature trees (Whitney 1994). Fire sizes were variable depending on the terrain, weather and fuel conditions. Fires spread without human suppression, burning out when they ran into natural fire breaks, the weather changed to rain or snow, or the fire encountered a less combustible fuel type.

Fires of moderate and greater intensity burned less frequently (e.g., every 40 to 50 years) and coincided with regional or subcontinental drought (Cwynar 1977, Guyette et al. 1999). Fires burned more extensively and caused greater mortality to overstory trees in drought years. Catastrophic fires intense enough to cause stand replacement were least common in eastern hardwood forests. The periodicity of severe, stand replacement fires is not well documented.

Fires were common in bottomland areas, and wetlands burned during drought periods. Europeans found large prairies and openings along the valleys of rivers, such as the Missouri and Mississippi, the result of Indian fires (Catlin 1844, Williams 1989, Nelson et al. 1999).

Native American populations declined drastically due to European diseases during the 16th and 17th centuries. As many as 80 percent of the people in a tribe perished in disease epidemics (Williams 1989, Delcourt et al. 1993). The frequency of fire was greatly reduced during this period of low population (Guyette 1995, Guyette et al. 1999). Migrating Indian tribes, displaced from their ancestral lands in the East, carried fire back into areas of low population in the CHR, increasing fire frequency during the 18th century (Table 1). By the early 1800s, European settlers were pouring into the CHR.

European Fire

European settlers continued Indian burning practices, but often increased fire frequency and carried fire into more remote areas (Table 1). In general, fires burned most frequently during the period 1850 to 1930, when Europeans were busy converting the landscape into farms and villages (Pyne 1982). Fires, and now other forest disturbances such as grazing, logging, and fuelwood cutting, maintained the open, park-like character of the forests, with understories dominated by grasses and herbaceous plants. Frequent burning, grazing, and logging created forests of sprout origin dominated by oaks.

Fires burned extensively following wholesale logging of the forests. During this period, many of our most famous fires burned millions of acres of cutover forests and took the lives of many people in the Lake States. The cycle of

Table 1. Estimated annual wildfires per million acres based on fire histories in the Upper Current River watershed in the Missouri Ozarks for a range of average fire sizes (Guyette 1995).

		Average fire size acres (ha)			
		100 (40.5)	500 (202.3)	1,000 (405)	5,000 (2,023.5)
Period	MFI[a]	Fires per year per million acres			
Native American I (1581 to 1700)	15.8	632	126	63	13
Native American II (1700 to 1820)	8.9	1,123	225	112	22
European settlement (1820 to 1940)	3.7	2,703	540	270	54

[a] MFI = mean fire interval in years. Mean fire interval data for the Upper Current River watershed (approximately 1 million acres: 445,000 ha) represent the averages of 23 fire history sites.

logging and burning also greatly reduced the extent of pine forests in the CHR. After the mature, seed-bearing pines were harvested, intense slash fires and repeated burnings eliminated or greatly reduced the abundance of pine reproduction (Record 1910, Guyette and Dey 1997b). Oaks succeeded the pines and shade-tolerant mesophytic hardwoods (Abrams 1992). Oaks expanded their dominance on mesic, highly productive sites with frequent and widespread burning.

The widespread suppression of wildland fires began in the 1930s and 1940s in the CHR; however, in the Ozark Highlands wildland fires were common until the 1950s (Pyne et al. 1996). The amount of acres burned by wildland fires has dropped drastically over the past 100 years. At the beginning of the 20th Century, the fire rotation period was 90 years in Michigan and 50 years in Pennsylvania (Whitney 1994). During the initial period of European settlement in the Missouri Ozarks, mean fire intervals averaged around three years (Cutter and Guyette 1994). Now, the fire rotation period is estimated to be more than 700 years in Missouri (Table 2).

At the outset of the fire suppression period, modern oak forests developed rapidly across the CHR, replacing savannas, barrens and prairies, and dominating old fields and cutover lands. Oak advance reproduction in these systems grew quickly into closed canopy forests following the cessation of fire (Curtis 1959, Grimm 1984). However, with continued fire suppression, oak forests are being replaced by more shade-tolerant, mesophytic species such as the maples.

The Significance of Human-caused Fire

The balance between human-caused and natural fires is of importance in the debate about how we should conserve or restore our "natural" heritage. Natural fires generally refer to those that result from ignition sources other than human. Lightning is the primary ignition source of natural fires. Fire managers in Ohio, Missouri, Michigan, and other Midwestern states have observed that lightning causes 2 percent or less of all wildfires (Westin 1992, Ohio Depart-

Table 2. Estimated fire rotation periods for the modern period in eastern North America.

Region	Fire rotation period	Reference
Missouri Ozarks	715 years	Westin 1992
Pennsylvania	910 years	Whitney 1994
Lower Michigan	1,400 to 2,000 years	Whitney 1994
Southern Illinois	900 years	Haines et al. 1975

ment Natural Resources 2000, Michigan Department Natural Resources 2000, Tennessee Forestry 2000). From another perspective, lightning causes less than 1 fire per 1 million acres (400,000 ha) annually in the CHR, based on weather and fire records from the past century (Schroeder and Buck 1970). Thunderstorms occur on average 30 to 50 days each year over much of the CHR (Baldwin 1973). The highest occurrence (50 to 70 days per year) of thunderstorms is in the southwestern portion of the region. Most thunderstorms in the CHR are accompanied by heavy rainfall, which reduces the likelihood of fires spreading from lightning strikes. Also, lightning-caused fires are less likely to spread in the summer, when vegetation is in leafout and fuels have high moisture contents. In contrast, humans have caused an average of 105 fires per year per 1 million acres (400,000 ha) in southern Missouri (1970 to 1989), which includes one of the largest contiguous forested areas in the CHR, the Ozark highlands.

How has the role of humans as ignition sources changed since the Native American period? Although documented fire histories are rare in eastern North America, we do have a wealth of information on historic fire regimes in the Missouri Ozarks. Within the Upper Current River watershed, which encompasses some 1.1 million acres (445,000 ha), Guyette (1995) reconstructed fire histories for 23 sites distributed throughout the area. The composite fire history for all these study sites is presented in Table 1 by historic period. The Native American I period refers to a time when Indian populations were decimated by diseases introduced by Europeans. Fire was less prevalent (mean fire interval [MFI] = 15.8) in the Ozarks than later periods. Human populations began to recover during the Native American II period due to increases in local populations and immigration of eastern tribes. Coincidently, fires burned the Ozark forests more often. The greatest period of fire activity was during initial settlement of the Ozarks by the Scotch/Irish and other European settlers beginning in the 19^{th} century.

Historic levels of fire occurrence are substantially greater than the rate of natural fires caused by lightning in the Missouri Ozarks (Table 1). Based on Guyette's (1995) data, a range of average fire sizes from 100 acres (40 ha) to 5,000 acres (2,023 ha) was used to estimate annual fires per 1 million acres (400,000 ha), and to evaluate the contribution of humans to the overall frequency of fire. It is difficult to establish actual fire sizes in the past, however, we do know that fires in the Missouri Ozarks averaged 100 acres (40 ha) in size during the early stages of fire suppression (1930s to 1940s) (Westin 1992), and that average fire size was certainly larger than this when fires burned freely. The high level of fire activity in historic times (Table 1) relative to the background level of lightning fires is largely a result of human ignitions. Widespread use of fire by Native Americans and early European settlers is well documented, and it is unlikely that the level of lightning has changed much in the past 400 years. In the absence of humans, natural fire would have shaped the development of vegetation in the CHR and provided opportunities for oaks to persist. However, the current abundance of oak and other fire dependent genera would not exist if it were not for human-fire.

The Need to Manage Oak Forests

Today, humans start most of the wildfires in the CHR, as they did in the past, but the area burned annually has been dramatically reduced by effective detection and suppression programs. Over the past 30 years, the number of human-caused wildfires in forest protection districts has been relatively constant in such states as Missouri, Ohio and Tennessee, where on average from 1,000 to 3,000 wildfires burn per year. The number of wildfires can double in a drought year. What is notable is that within the past 70 years, average fire size has been drastically decreased from about 100 acres (40.5 ha) to just 10 acres (4 ha) or less.

In the absence of fire, disturbances that result in small openings in the forest canopy accelerate succession to shade tolerant species. How private landowners harvest their forest has a tremendous effect on the sustainability of oak forests because they own most of the forest lands in the CHR, and provide the bulk (e.g., 90 percent) of the annual hardwood production (Birch 1996). Unfortunately, most of the harvesting is done without any forest management plan. Although it is difficult to quantify the amount of timber harvested by regeneration method, common harvest techniques on unmanaged private land include selective cutting or high grading and diameter limit cutting. These rogue harvest practices create small gaps in the overstory canopy, which usually do not favor oak development, especially on the more productive sites. Harvest by these methods often results in understocked stands of reduced quality and value.

With the suppression of wildland fires, wind has become one of the last natural forces capable of altering forest character on a landscape basis (Greenberg and McNab 1998). Wind storms create regeneration opportunities by the windthrow of a single or several overstory trees, or by catastrophic loss of the overstory over larger areas. The small scale disturbances are by far the most common form of wind damage, regardless of forest type. These gaps range in size from 0.01 to 0.1 acre (0.004 to 0.04 ha) (Runkle 1982, 1990, Lorimer and Frelich 1994).

The annual rate of small canopy gap formation in old-growth forests ranges from 0.4 to 2.0 percent for a variety of temperate hardwood forests (Runkle

1990). At these rates of canopy gap formation, complete overstory turnover can occur in < 250 years. For mesophytic hardwood old-growth forests, rotation periods range from 50 to 250 years for disturbances that cause small canopy gaps (e.g., 0.1 acre:0.04 ha) (Table 3). Shade tolerant species dominate regeneration in these small canopy gaps.

Storms such as tornadoes and thunderstorms that cause large scale windthrows are rare. Tornadoes can cause catastrophic damage in forested landscapes, although their damage is usually localized, and effects only a small proportion (e.g., < 0.04 percent) of area in the CHR (Jamison 1978). Thunderstorms can produce severe vertical winds known as downbursts, and multiple downbursts can collectively cause damage over a large forested area. However, the frequency of storms that cause large-scale forest damage is low, resulting in extended rotation periods at the landscape-level (Table 3). Shade intolerant, pioneer species often dominate regeneration in these larger windthrow areas.

Conclusion

Oak species are adapted to thrive in environments characterized by periodic disturbances such as fire, drought and herbivory. Disturbances that cause repeated shoot dieback favor oaks over their competitors. Historically, frequent fires created open forest conditions by limiting the development of a shade tolerant subcanopy and by reducing overstory stocking, which allowed the shade intolerant oaks to persist and grow as large seedling sprouts, and to accumulate as advance reproduction in the understory. Upon subsidence of the disturbance, large oak seedling sprouts grow vigorously and are able to dominate growing space made available by the past disturbance.

Many oak forests have developed shade tolerant understories and increased overstory stocking over the past 70 years of fire suppression. The resulting low light condition at the forest floor limits oak regeneration and promotes the dominance of the shade tolerant species. Subsequent timber harvesting, regardless of method, releases the shade tolerant advance reproduction. In larger harvest areas, fast growing species such as yellow-poplar dominate the regeneration. Oak advance reproduction is either lacking or is too small to compete well.

For thousands of years, humans have been instrumental in creating the disturbances that have favored the development of our oak forests, primarily through the use of fire. More recently, timber harvesting, open range grazing and other commercial uses of the forests have added to the array of disturbances that favor oak dominance. But fire suppression and the virtual elimination of fire from the forests has radically altered forest successional processes to the detriment of oak and the benefit of it's competitors.

Table 3. Rotation periods[a] for wind disturbances in common forest types of the eastern United States. Disturbance type is catastrophic winds that cause stand regeneration unless otherwise noted.

Rotation period in years	Forest/disturbance type	Region	Reference
50 to 250	Old-growth mesophytic hardwoods; small canopy gaps	Eastern U.S.	Runkle 1982, 1990
1,200	Hemlock/white pine/northern hardwoods; more than 2.5 acres	Michigan and Wisconsin	Canham and Loucks 1984
2,900	Hemlock/white pine/northern hardwoods; more than 2,500 acres	Wisconsin	Canham and Loucks 1984
300	Old-growth hemlock/northern hardwoods; disturbance that destroys 30 to 50 percent of canopy	Michigan	Frelich and Lorimer 1991
1,500	Old-growth hemlock/northern hardwoods; disturbance that destroys more than 60 percent of canopy	Michigan	Frelich and Lorimer 1991
5,600-6,000	Old-growth hemlock/northern hardwoods; tornadoes with greater than 75 mile per hour winds	Wisconsin and Michigan	Frelich and Lorimer 1991
1,000-2,000	Hemlock-white pine/northern hardwoods	Pennsylvania and New York	Whitney 1990
2,000	Central hardwoods, tornadoes	Indiana	Whitney 1994

[a] Rotation period is the time required for an area equal to the size of the study area to be affected by a specific disturbance regime. For a given region, it is the inverse of the percentage of area affected on a yearly basis by a specific size and type of disturbance (Whitney 1994).

Planned and repeated human disturbances are necessary to sustain oak forest ecosystems. Silvicultural practices that regulate overstory stocking, limit shade tolerant understories and promote accumulation of large oak advance reproduction are key for the maintenance of forest composition and diversity. Timber harvesting in combination with understory competition control using prescribed fire, herbicides or mechanical cutting can be used to create favorable stand structure for development of oak advance reproduction. Underplanting oak seedlings in shelterwood understories can expedite the development of large oak advance reproduction. Landowners must adopt oak regeneration as a management objective and be willing to invest in appropriate silvicultural practices needed to sustain oak.

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Enhanced Avian Diversity in Wisconsin Pine Barrens through Aggregated Timber Harvest

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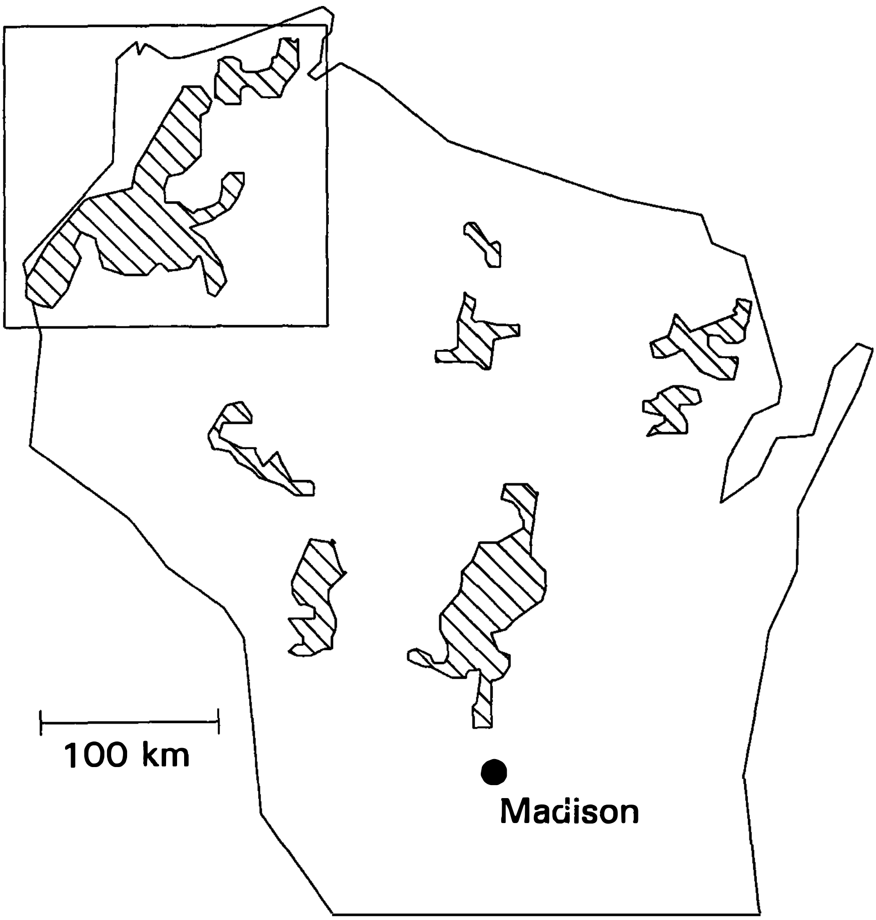
The pine barrens of northwestern Wisconsin are defined by areas of xeric sands with vegetation that is highly susceptible and adapted to fire (Figure 1). Fire frequency in the region prior to settlement by Europeans is unknown (Canham and Loucks 1984), but fires were sufficiently large and frequent to remove most timber and much woody vegetation in some areas, creating large openings called barrens (Curtis 1959). Prior to settlement by Europeans, barrens are estimated to have covered 930,000 hectares in Wisconsin (Curtis 1959) and 2 million hectares in Wisconsin, Minnesota and Michigan (Vora 1993).

Presently, large areas of early successional vegetation and many associated species are gone from northwestern Wisconsin. With the advent of fire control in the 1920s, secondary succession and tree planting have resulted in almost complete forestation of the pine barrens, reducing the size and number of early successional habitat patches (Curtis 1959, Gregg 1987, Mossman et al. 1991). Increased anthropogenic edge, decreased patch size, altered microclimate, and altered disturbance regimes typical of managed landscapes (Godron and Forman 1983, Hansson 1992) are all exhibited in Wisconsin pine barrens.

Early successional vegetation in the pine barrens provides essential habitat for many shrubland and some grassland (collectively referred to in this paper as savanna) bird species, many of which are declining locally and across their range (Sauer and Droege 1992, Askins 1993, Thompson et al. 1993, Sample and Mossman 1997). Several savanna bird species found in the pine barrens are area-sensitive, requiring large blocks of habitat to be present or maintain viable populations (Temple 1992, Vickery et al. 1993, Herkert 1994, Niemuth 1995, Sample and Mossman 1997). All require early successional vegetation, which, in the pine barrens, was historically created or maintained by wildfire. Because fire control has virtually eliminated wildfire and resultant large patches of early successional vegetation from the pine barrens, disturbance is primarily limited to scattered clearcuts and small, quickly extinguished wildfires. The largest re-

Figure 1. Historical Wisconsin pine barrens, after Curtis (1959). Data upon which simulation is based were collected within region bounded by square.



maining patches of early successional vegetation in the pine barrens are maintained with prescribed fire (Gregg 1987, Mossman et al. 1991), but these sites might be too small to support viable populations of area-sensitive species such as sharp-tailed grouse (*Tympanuchus phasianellus*) (Gregg 1987, Temple 1992). Timber production, mixed land ownership, management costs, and recreational development prevent the use of large-scale prescribed fire in the region.

Savanna birds in the pine barrens readily use openings created by timber harvest (Mossman et al. 1991, Niemuth 1995, Gregg and Niemuth unpublished data). Species richness of savanna birds in patches of early successional habitat created by timber harvest is strongly correlated with patch size, and is not significantly different from species richness in patches created or maintained by fire (Niemuth 1995). However, small size and isolation of many patches of early successional habitat limit their effectiveness at harboring savanna bird species (Gregg 1987, Mossman et al. 1991).

Management has been proposed that would use a landscape-level rotation of clearcuts to create habitat for savanna species in the pine barrens (e.g., Vora 1993, Strand and Epperly 1995). Similar harvest patterns have been proposed for restoring large-scale disturbance patterns with the intent of reducing fragmentation and, over time, creating large blocks of forest for the benefit of forest interior species (Li et al. 1993, Hansen et al. 1993). Here we present a spatial simulation model that examines the effects of disturbance size and distribution on landscape characteristics and diversity of savanna bird species in a Wisconsin pine barrens landscape. The model offers insight into reversing fragmentation of a disturbance-based ecosystem. It shows how management may influence presence of savanna birds in a human-dominated landscape. The predominant human use of Wisconsin pine barrens is production of pulp; our model provides guidelines for enhancing spatial patterning of clearcuts to provide habitat for area-sensitive savanna birds in early successional habitat patches created by timber harvest. Unlike many studies of habitat fragmentation, which focus on forest fragmentation, our study focuses on the reverse— well-defined patches of early successional habitat created by disturbance and bounded by forest.

Methods

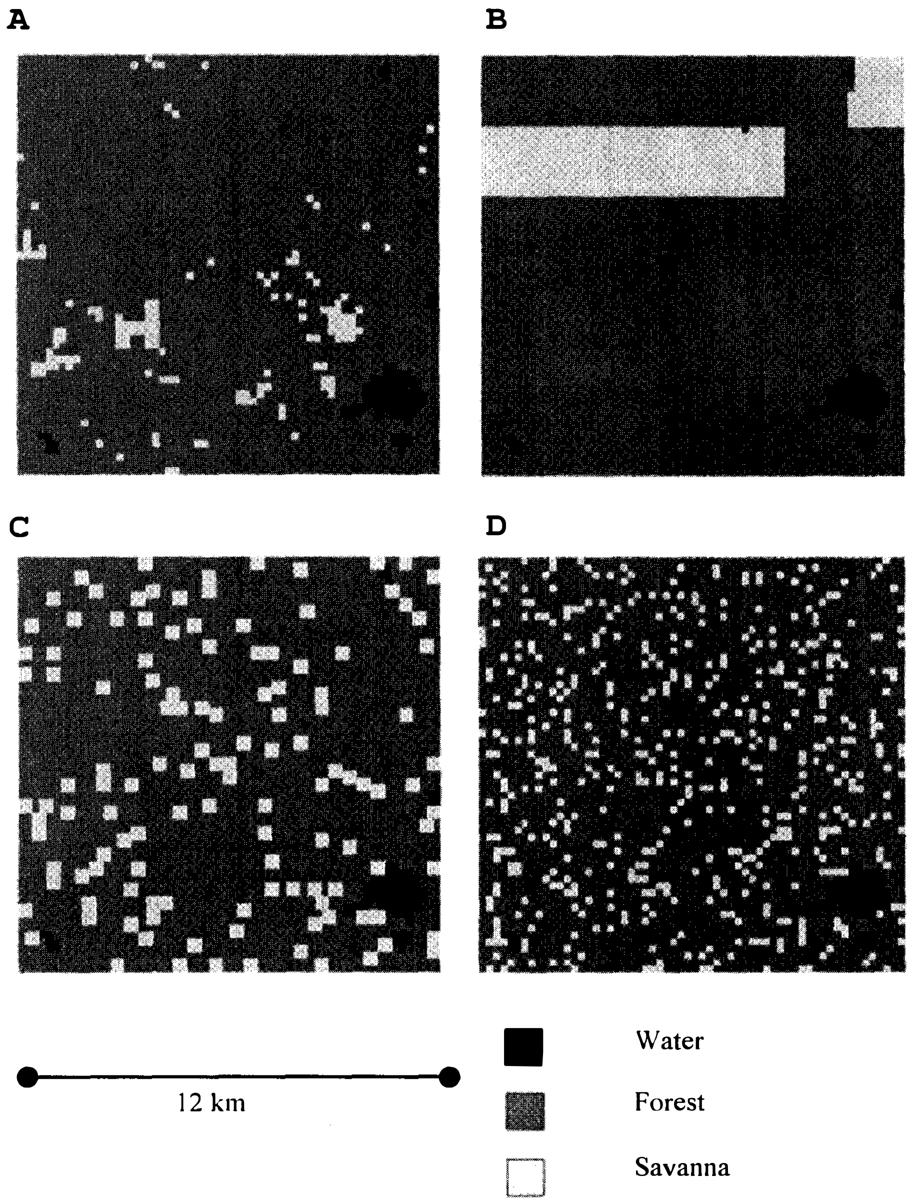
Timber Harvest Simulation

The model was written in QuickBasic® and interfaces with the Idrisi® geographic information system. The initial simulation landscape resembled land cover present in 1995 and consisted of a 60 by 60 matrix of cells 200 meters by 200 meters (4 ha each). This size (14,400 ha) is comparable to the proposed landscape management area in the pine barrens (Strand and Epperly 1995) and other areas of public and private land suitable for landscape-level management in northwestern Wisconsin.

The initial simulation landscape was classified as 2.3 percent water, 7 percent forest land that was 10 years or less old, 38.9 percent 20-year old, 29.3 percent 30-year old, and 22.5 percent 50-year old. Classifications did not exactly represent forest age in the landscape, but captured existing heterogeneity caused by water bodies and previous timber harvest patterns (Figure 2a).

Age of landscape cells was incremented annually, and maturity of timber within a cell was based on age of the cell. Harvest was based on clearcutting of cells; annual harvest for all simulations was 288 hectares (approximately 2 percent of the forested landscape), producing a 50-year harvest rotation. Harvest

Figure 2. (A) Initial simulation landscape prior to harvest modeling. (B) Simulation landscape at year 200 of aggregated harvest. (C) Simulation landscape at year 200 of randomly placed 16-hectare clearcuts. (D) Simulation landscape at year 200 of randomly placed four-hectare clearcuts. The amount of landscape harvested is identical under each regime. All cells greater or equal to 7 years of age are considered unsuitable for savanna birds and are classified as forest.



was simulated for 200 years under each of three clearcut harvest options: (1) all clearcut cells placed adjacent to each other and the previous year's clearcuts; (2) 16-hectare clearcuts placed randomly in the landscape; and (3) four-hectare clearcuts placed randomly in the landscape (Figure 2). Under all options, timber in a cell 30 years old or younger was not harvested because the timber was not considered sufficiently large for pulp. We considered clearcuts younger than 7 years old to be early successional habitat suitable for savanna birds. Cells 7 years or older were considered forest matrix and unsuitable for savanna birds.

We quantified six landscape characteristics for each simulation year under each harvest regime.

1. Number of patches, defined as the number of disjunct forest and early successional patches in the landscape. Lakes (n = 9) were not included, because harvest patterns did not affect their number.
2. Edge, defined as kilometers of boundary between forest and early successional habitat cells.
3. Mean patch size, defined as the mean area (hectares) of all forest and early successional habitat patches in the landscape.
4. Maximum early successional habitat patch size, defined as the area (hectares) of the largest contiguous patch of early successional vegetation in the landscape.
5. Early successional interior habitat, defined as the area (hectares) of all early successional habitat (cells less than 7 years) in the landscape more than 200 meters from forest edge.
6. Forest interior habitat, defined as the area (ha) of all forest (cells 7 years or older) in the landscape more than 200 meters from clearcut edge.

Species Presence as a Function of Patch Size

We sampled savanna birds at two scales in 40 early successional habitat patches in northwestern Wisconsin during 1993 and 1994 (Niemuth 1995). Patch size was the strongest predictor of the presence of savanna bird species in patches, although vegetation characteristics also influenced species presence within patches (Niemuth 1995). Species presence was strongly nested, where species present in small patches were likely to be present in all larger patches, and area-sensitive species were present only in large patches (Figure 3). We used this simple pattern to model the presence of bird species as a function of patch size.

To test the ability of patch size to predict species presence, we paired the 40 habitat patches by size to form two subsets of 20, each of which was used to validate predictions from the other subset. We estimated logistic regression coefficients for all species in each group using patch size as the predictor variable and the presence or absence of species in each patch as the response

SPECIES	X DENOTES SPECIES PRESENCE																																							FREQUENCY
SAVANNA SPARROW																																									X	1
BOBOLINK																																									X	1
GRASSHOPPER SPARROW																																								X	X	2
HORNED LARK																																		X						X	X	3
WESTERN MEADOWLARK																																				X		X	X	X		4
BARN SWALLOW																															X		X							X	X	4
NORTHERN HARRIER																																X		X			X	X		X	X	6
SHARP-TAILED GROUSE																																X		X	X	X	X		X	X	X	8
KILLDEER																			X												X	X			X		X	X	X	X	X	9
UPLAND SANDPIPER																											X			X	X		X		X	X	X	X	X	X	X	11
AMERICAN KESTREL															X													X				X	X	X	X	X	X	X	X	X	X	12
COMMON NIGHTHAWK																						X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	17
MOURNING DOVE										X			X			X						X	X		X	X	X			X	X	X	X	X	X		X	X	X	X	X	19
FIELD SPARROW												X			X				X		X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	22
AMERICAN GOLDFINCH											X		X					X	X			X	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	22
BROWN THRASHER								X								X		X			X		X	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	22
BREWER'S BLACKBIRD													X						X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	23
TREE SWALLOW												X			X			X	X			X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	23
RED-TAILED HAWK										X	X		X					X		X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	24
EASTERN KINGBIRD											X	X	X		X		X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	27
EASTERN BLUEBIRD				X		X						X		X	X	X	X	X			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	27
VESPER SPARROW			X			X	X						X			X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	29
RUFOUS-SIDED TOWHEE	X				X	X	X		X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	33
BROWN-HEADED COWBIRD		X	X		X			X	X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	34
CLAY-COLORED SPARROW	X	X			X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	37
	0 to 10 ha											10 to 100 ha														100 to 1000 ha							>1000 ha				

Figure 3. Presence of 25 species of savanna birds at 15 fire-created and 25 clearcut early successional habitat sites (Niemuth 1995). Sites arranged from smallest (<1 ha, left) to largest (>2,000 ha, right). The far right column shows frequency of occurrence for each species.

variable. We then calculated the probability of the i^{th} species occurring ($E\{p_i\}$) using the logistic response function:

$$E\{p_i\} = \exp(b_{oi} + b_{1i}(A)) / 1 + \exp(b_{oi} + b_{1i}(A))$$

where b_{oi} is the logistic regression intercept for $species_i$, b_{1i} is the regression slope for $species_i$, and A is the $\log_{10}$ area (ha) of each patch. Species were predicted to be present in a patch if the calculated probability was 0.5 or greater. Predictions from each set were compared to observed patterns of presence and absence in the other set.

Species Presence in the Simulation Landscape

For 22 savanna bird species observed in clearcuts, we estimated the probability of the i^{th} species occurring in a patch ($E\{p_i\}$) using the logistic response function estimated from all 40 early successional habitat patches. Probability of occurrence was estimated for each species for the largest open habitat patch each simulation year. If the probability exceeded a probability randomly generated by the model (mean = 0.5), the species was considered present. Presence of species was summed for each year to calculate annual species richness. The model assumes no changes in silvicultural methods from sampled sites (i.e., adequate snags, grasses, and shrub cover are assumed to be present for species requiring them).

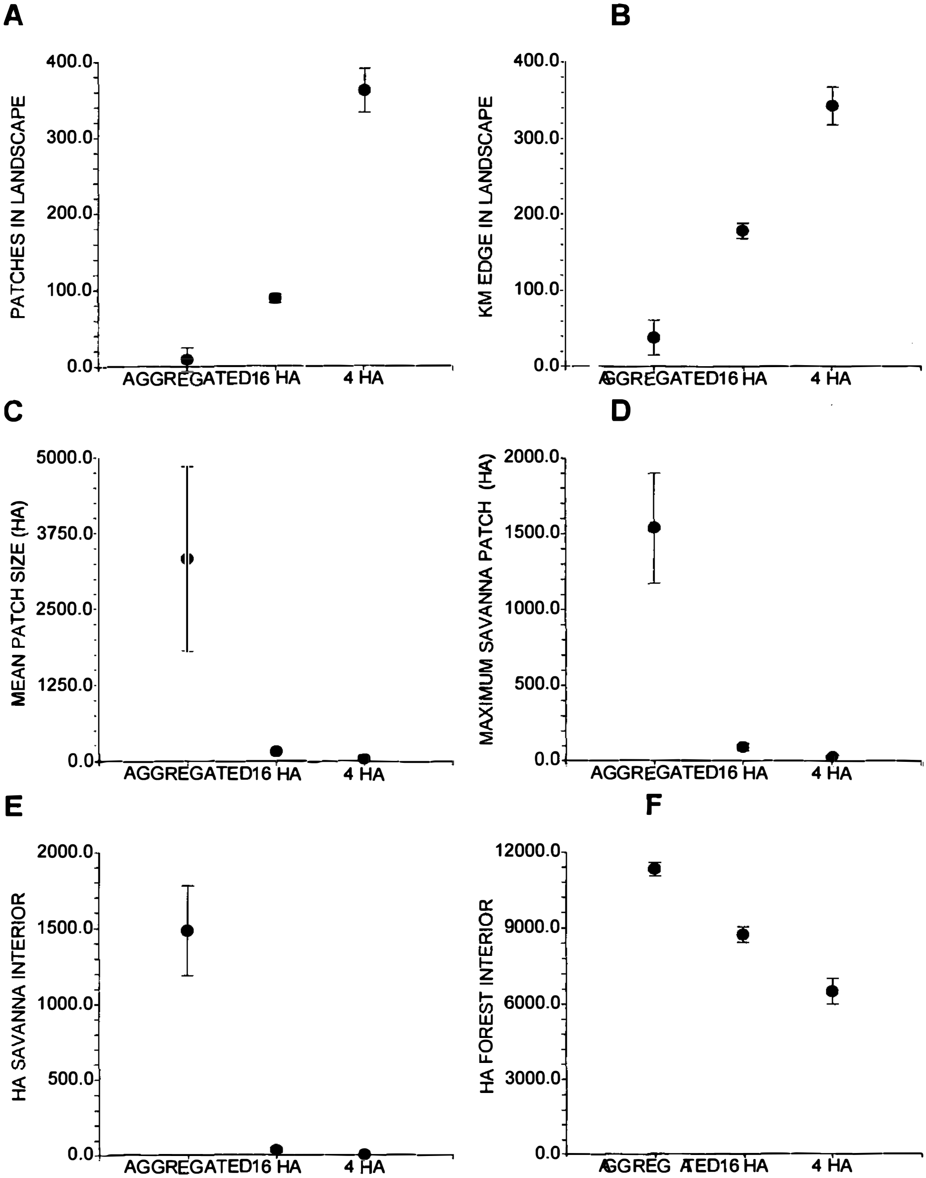
Results

Landscape Measures

Landscape measures were markedly different under each of the three harvest regimes (Figures 2 and 4), with the landscape being most fragmented under the random four-hectare cutting regime and least fragmented under the aggregated cutting option. When aggregated, clearcuts created large patches of early successional habitat, and the remaining forested portion of the landscape was undisturbed by harvest (Figures 2 and 4). Under both random cutting options, clearcuts were dispersed and only occasionally located adjacent to existing openings or other clearcuts, resulting in a fragmented landscape of small, isolated early successsional habitat patches (Figure 2). Maximum early successional habitat patch size was two orders of magnitude greater for aggregated cuts than for 16-hectare or 4-hectare cuts (Figure 4).

Amounts of clearcut interior habitat and forest interior habitat were also significantly affected by harvest method. Aggregated cutting created blocks of early successional habitat with large amounts of interior, whereas single 16-hectare and 4-hectare openings had no interior given our 200-meter delineation of interior. Creation of clearcut interior habitat under the random harvest op-

Figure 4. Mean landscape characteristics under the three harvest regimes for 200-year simulation. (A) Number of forest and early successional habitat patches. (B) Kilometer of edge in the landscape. (C) Size of forest and early successional habitat patches. (D) Size of largest early successional habitat patch each year. (E) Area of early successional interior habitat (>200 meters from edge). (F) Area of forest interior habitat (>200 meters from edge).



tions happened only by chance when multiple clearcuts were located adjacent to each other in a clumped configuration. Mean area of clearcut interior habitat was greatest under the aggregated cutting regime, while 16-hectare and 4-hectare cuts created little interior early successional habitat (Figures 2 and 4).

Under the aggregated cutting option, harvest occurred in one portion of the landscape, and the remainder of the landscape was undisturbed. Openings created under the random harvest options fragmented the forest matrix (Figure 2). Forest interior habitat was greatest under the aggregated cutting regime and declined as clearcut size decreased (Figure 4). Similarly, two other measures of fragmentation—number of patches and kilometers of edge—were lowest under the aggregated cutting regime and highest under the 4-hectare cutting option (Figure 4).

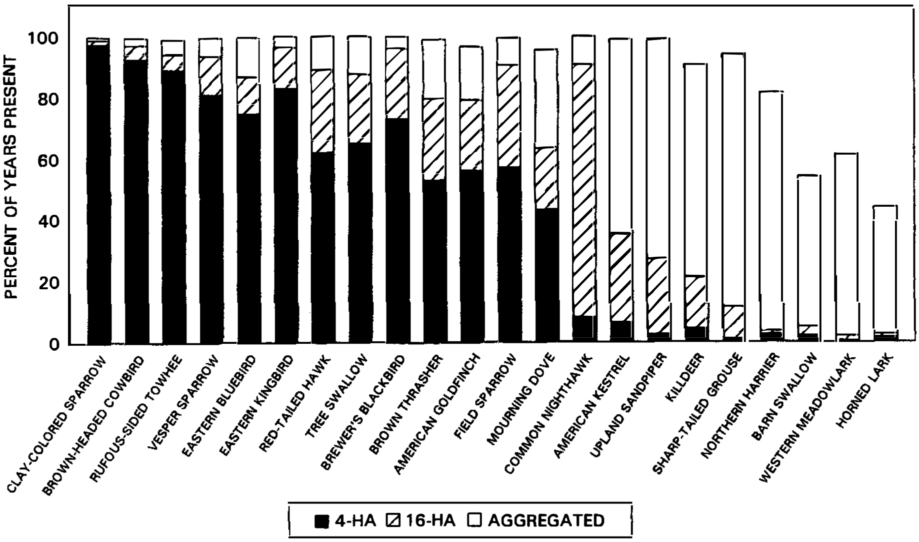
Species Presence as a Function of Patch Size

Patch size was a strong predictor of observed patterns of savanna bird presence in patches. Predicted membership of species in each of the validation subsets was high, with 789 of 920 (85.8 percent) cases correctly classified. Classification success per species in subsets of 20 patches ranged from 60 percent to 100 percent.

Species Presence in the Simulation Landscape

Under the four-hectare harvest regime, only 5 of the 22 savanna bird species were present in the simulation landscape more than 80 percent of the time (Figure 5). When clearcut size was increased to 16 hectares, 11 species were present more than 80 percent of the time and the frequency of occurrence for area-sensitive species increased moderately. Large patches of early successional vegetation created by aggregated clearcutting provided habitat for area-sensitive species not found at smaller sites. Under aggregated harvest, 19 of 22 species were present in the simulation landscape more than 80 percent of the time, including species requiring large habitat blocks such as the Western meadowlark (*Sturnella neglecta*), horned lark (*Eremophila alpestris*), sharp-tailed grouse, Northern harrier (*Circus cyaneus*), upland sandpiper (*Bartramia longicauda*), American kestrel (*Falco sparverius*), and common nighthawk (*Chordeiles minor*). Greatest richness (mean ± SD) of savanna birds occurred under the aggregated cutting regime (20.1 ± 1.2), followed by the 16-hectare (13.5 ± 1.7) and 4-hectare (9.6 ± 1.8) options.

Figure 5. Percentage of the 200-year simulation that individual species were present for each of the three timber harvest regimes. Percentages should be read to the top of the corresponding bar segment for each harvest regime.



Discussion

Aggregation of clearcuts can be used to enhance patch characteristics and avian diversity "Wisconsin pine barrens." Even though the amount of timber harvested annually was identical under each simulated cutting regime, different harvest patterns dramatically changed maximum patch size (Figure 4) and other landscape characteristics, providing for increased presence of area-sensitive savanna bird species. The model's timber harvest patterns are far more deterministic than natural disturbance regimes, and they may have different effects on the landscape and its organisms. For example, natural fire regimes are strongly influenced by climatic conditions and can be quite variable (Clark 1988), and the biological consequences of anthropogenic edge may differ from those of natural edges (Paton 1994). Nevertheless, the simulation provides insight into management of human-dominated landscapes, even if the processes it models do not duplicate pre-settlement disturbance patterns.

Many biotic and abiotic processes function at the landscape level, and large geographic areas often are necessary to maintain species and the ecosystem processes upon which species may depend (Pickett and Thompson 1978, Noss and Harris 1986, Noss 1990, Baker 1992). Large habitat patches created under the aggregated harvest regime are able to harbor area-sensitive savanna species not found in small patches (*see* Herkert 1994, Vickery et al. 1994, Niemuth 1995). Several large patches may be required to maintain viability of populations, as well as serve as sources to colonize other habitat patches (Pimm et al. 1988, Saunders et al. 1991, Temple 1992). In addition, large patches have a relatively greater amount of interior habitat relative to small patches, reducing probability of edge-related nest losses (Niemuth and Boyce 1997).

Assuming that the number of forest interior and generalist bird species in the landscape is constant, the aggregated harvest regime can-—compared to dispersed harvest—result in increased avian species richness on local and regional scales. The aggregated harvest option, which maximizes diversity of savanna birds, also causes less fragmentation of the forested portion of the landscape, which may increase presence and reproductive success of forest-interior species (Blake and Karr 1987, Rolstad 1991, Wenny et al. 1993, Hagan et al. 1996). Spatial configuration of patches is not considered in our model, as birds are assumed to be able to colonize available habitat anywhere in the landscape.

This model specifically addresses landscape characteristics and savanna birds, although we anticipate benefits for other species, as well. For instance, wild blue lupine (*Lupinus perennis*), which is found in southern portions of northwestern Wisconsin pine barrens, is frequently associated with disturbed soil in clearcuts (personal observation). Blue lupine is the larval host plant for the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*). Adjacent openings created by aggregated harvest would continually create habitat into which Karner Blue butterflies might disperse.

Little is known about the effects of timber harvest on other taxonomic groups inhabiting pine barrens early successional habitat. Community composition and ecosystem processes almost certainly will differ between disturbance types. For example, vegetation structure and species composition differ in several ways between early successional habitat patches created by fire and timber harvest (Niemuth and Boyce 1998). However, many pine barrens plant species respond favorably to increased light and temperature of canopy opening, whether the opening is caused by fire or other disturbance (Buell and Cantlon 1953, Vogl 1970). Also, mere presence of bird species in clearcuts does not mean that successful reproduction is taking place. But the largest and densest population of sharp-tailed grouse presently in Wisconsin is located in a complex of clearcuts created largely by salvage logging of jack pine infested by jack pine budworm (*Choristoneura pinus*) (N.D. Niemuth, unpublished data). These birds enjoy higher adult survival and nesting success than sharp-tailed grouse on nearby reserves managed with prescribed fire (Connolly, Niemuth and Lutz, unpublished data).

Landscape-level management can complement existing reserves to preserve biodiversity (Noss and Harris 1986, Wilcove 1989, Hansen et al. 1993, Wiens 1994). In the pine barrens, patch size and population viability of organisms inhabiting early successional habitat might be increased even more when large clearcuts surround an early successional habitat reserve. Colonization of newly created patches does not seem to be problematic for birds, but may be difficult for less vagile species. Existing early successional habitat reserves could function as species reservoirs, aiding dispersal of savanna species into nearby habitats created by clearcutting. Six wildlife management areas and eight permanent firebreaks exist as potential barrens reserves in northwestern Wisconsin. Wildlife management areas range in size from 250 hectares to 4,200 hectares; firebreaks range from 40 to 200 hectares. All are surrounded by industrial or public forestlands used primarily for timber production, from which early successional habitat could be created through timber harvest.

Most early successional habitat reserves in northwest Wisconsin were established and are maintained in openings created by wildfires that occurred in the 1930s and 1940s or failed attempts at agriculture (Vogl 1964, Vogl 1970, Vora 1993). These reserves are spatially static, and because of repeated burning they have lost much of the structural and vegetative diversity characteristic of openings created by wildfires (Mossman et al. 1991, Niemuth and Boyce 1998).

Unlike present reserves of early successional habitat, the pre-settlement barrens landscape was dynamic, undergoing a variety of successional stages depending on frost, fire frequency and intensity, topography, differences in soil type, edaphic conditions and climate (Curtis 1959, Vogl 1964, Vogl 1970). The aggregated clearcutting scheme that we have modeled is analogous to historic disturbance patterns in that it is dynamic, with harvest moving across the landscape and patches passing through successive seral stages. Yet the modeled disturbance is far more deterministic than pre-settlement disturbances. As researchers learn more about pre-settlement conditions and disturbance patterns (e.g., Radeloff et al. 1999), harvest could be modified to more closely mimic natural disturbance regimes with management prescriptions tailored to site-specific factors. For example, in areas that would be less likely to burn in a wildfire because of topographic or soil conditions, timber could be left standing or assigned to a longer harvest rotation. Compared to wildfire, timber harvest will have different effects on nutrient turnover, vegetation structure and vegetation species composition in the pine barrens (Niemuth and Boyce 1998). Leaving a residual stand of timber and burning following timber harvest could better mimic conditions created by fire.

As with all models, our simulation is a simplification that cannot approach the complexity of an ecosystem, yet provides insight into the effects of management alternatives on the ecosystem (Starfield 1997). In natural landscapes, existing landscape patterns may reduce the effectiveness of aggregated harvest regimes. Previous dispersed harvest may have created a matrix of timber stands of varying ages, and creating large blocks of open habitat may require some timber to be harvested before optimal maturity (Wallin et al. 1994). Edge effects and effective lifetime of clearcuts will be influenced by soil types, precipitation and pre-existing vegetation. Management activities including harvest methods, interval before tree planting at harvested sites, and other silvicultural practices also will influence edge effects (King et al. 1998) and effective lifetime of clearcuts. Finally, our model does not consider cultural features, such as roads, dwellings and land ownership patterns, or effects of landscape patterns on susceptibility to fire or insect infestations.

Similarly, the logistic response function on which our model is based was a strong predictor of species presence at the patch scale, but species presence within patches was influenced by a variety of other factors (Niemuth 1995). In natural landscapes and at smaller scales, avian presence will be influenced by disturbance type, soil type, vegetation composition, vegetation structure, and random variation (Niemuth 1995, Niemuth and Boyce 1998).

The aggregated harvest regime we advocate is not intended to duplicate presettlement conditions. But models such as this can be the first step in active adaptive management (*see* Walters and Holling 1990, Hansen et al. 1993) or more complex models of development (Starfield 1997). The model shows that aggregating clearcuts reduces fragmentation of early successional habitat and forest habitats in the landscape. Field experimentation can be used to validate model predictions and test hypotheses concerning further effects of management practices on organisms and processes in the pine barrens ecosystem. The pine barrens is a dynamic ecosystem, shaped by opposing forces of disturbance and succession, and is highly resilient. In Wisconsin pine barrens, aggregated cutting may retain the open landscape and enhance avian diversity while allowing for sustainable production of forest products.

Acknowledgments

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How to Reduce Gypsy Moth Effects on Central Hardwood Forests

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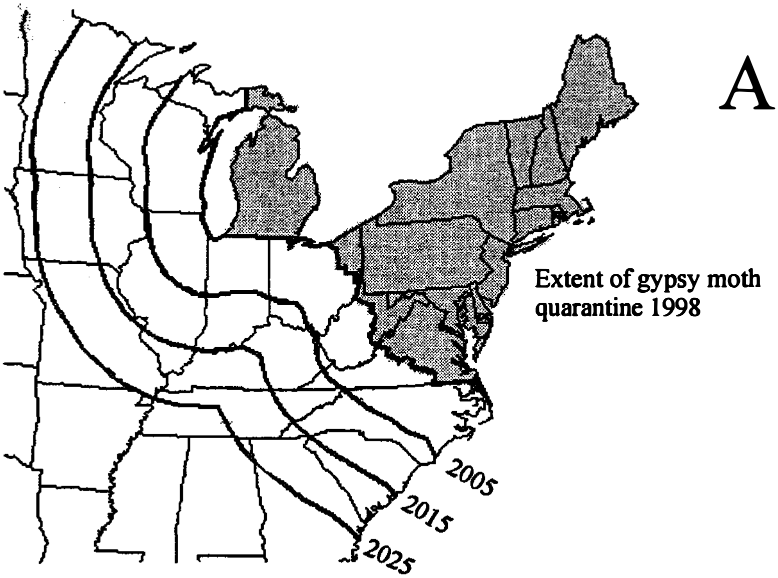
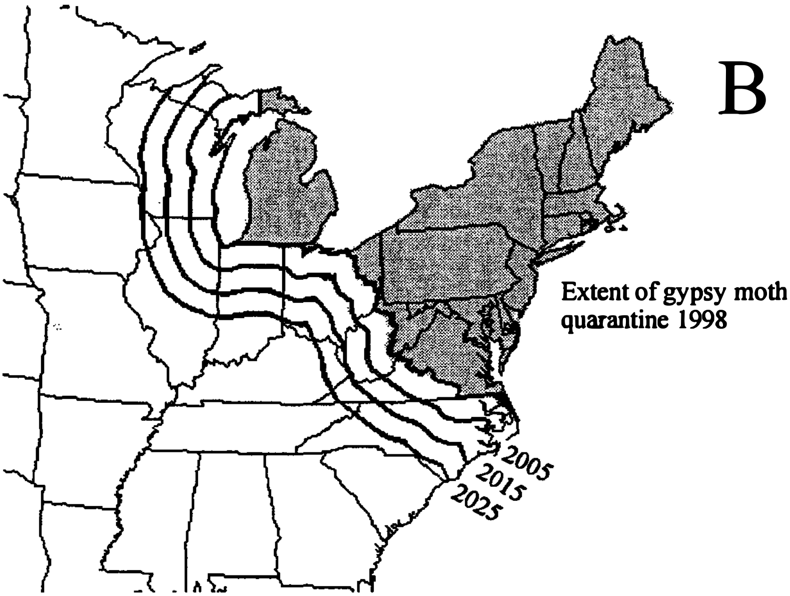
The gypsy moth *(Lymantria dispar)* was accidentally introduced from Europe into North America in 1869 (Liebhold et al. 1989). Early programs were established to eradicate the insect, including a quarantine to prevent spread and several different types of control treatments including egg-mass removal, spraying of larvae and pupae and removal of host trees. Despite these early efforts, gypsy moth became established in the New England area and heavily defoliated forests between 1911 and 1921. Another effort at containing the insect with a barrier zone was conducted from 1923 to 1941. A third effort followed from 1956 to 1958, using DDT; it was discontinued due to concerns about the safety of that chemical insecticide. During the 1960s and 1970s, the focus of gypsy moth management was on the aerial suppression of defoliating-level populations along with increased efforts at biological control of the insect to prevent the loss of forest values. During this time, the domestic quarantine restricting movement of gypsy moth-infested material remained in place since 1912. The quarantine was effective in limiting long-distance movement of gypsy moth but not the short-distance natural movement. An aggressive detection trapping and eradication program was successful in locating and eliminating small isolated populations that slipped through the quarantine. During the 1980s, emphasis was placed on Integrated Pest Management (IPM) approaches to gypsy moth management, and they became the staple of the federal and state management programs in the 1990s.

Gypsy Moth Spread and Status

Gypsy moth has spread throughout most of the northeastern United States and eastern Canada and is making considerable headway in the Lake States and Mid-Atlantic States (Figure 1). It continues to spread at a rate of about 13 miles (21 km) per year in warmer areas and about 5 miles (8 km) per year where the mean minimum temperature is less than 7 degrees Celsius (44.6°) (Liebhold et al. 1992). Gypsy moth currently infests approximately 25 percent of its potential range in eastern North America. At this rate of spread, it will

Figure 1. Gypsy moth 1998 quarantine line and projected spread of the gypsy moth to year 2005 and at 10-year intervals to 2025 with no slow-the-spread management (A) and with slow-the-spread management implemented (B).





take several decades for gypsy moth to invade the eastern potion of the continent completely (Figure 1). Although this rate of spread includes artificial transport by man, successful long-distance transport and establishment of gypsy moth in areas far from the current expanding front would shorten this time considerably. The maintenance of the gypsy moth quarantine together with detection and eradication of spot infestations of gypsy moth resulting from these successful long-distance moves remain key components of gypsy moth management.

Interest in renewing a program of slowing the expansion of the gypsy moth's range increased during the 1990s resulting in two demonstration or pilot projects. The success of these projects in slowing the spread of gypsy moth resulted in the funding of a national gypsy moth slow the spread (STS) management program in 2000. This program has the potential to slow the spread of gypsy moth more than 50 percent (Sharov and Liebhold 1998). The benefit of the program is the increase in time that it will take gypsy moth to reach the remaining areas of susceptible forests in the eastern United States, effectively postponing the effects of defoliation and mortality in these forests (Leuschner et al. 1996). The national STS barrier zone will stretch from Wisconsin to North Carolina (Figure 1B). A 50-percent reduction in rate of spread significantly reduces the forested area that will be infested by gypsy moth (Figure 1B).

Forest Susceptibility

Gypsy moths feed on a wide variety of trees (Liebhold et al. 1995), but they prefer oak (*Quercus*) trees to many other species. The preferred trees are called "susceptible species," and those not eaten at all by the gypsy moth are called "immune species." In between these two groups are a large number of species that can be eaten by gypsy moth but are not preferred by them: "resistant species." A few examples of species in each of these classes are listed in Table 1. The probability of gypsy moth defoliation during an outbreak is called stand susceptibility and is highly correlated to the proportion of basal area in susceptible tree species present in a stand (Table 2) (Gottschalk 1993). Maps of forest susceptibility to gypsy moth defoliation for the United States at the county level have been prepared using Forest Inventory and Analysis data (Figure 2, Liebhold et al. 1997a, 1997b). The central hardwood forests are among the most susceptible to defoliation of any forest area in the eastern United States. The Ozark-Ouachita Highlands area, in particular, contains 58 percent of its forested area in highly and very highly susceptible stands (Liebhold et al. in press).

Table 1. Three classes of gypsy moth host feeding preferences: susceptible, resistant and immune (Montgomery 1991, Liebhold et al. 1995).

Class	Species
Susceptible[a]	Apple (*Malus* spp.), American basswood (*Tilia americana*), bigtooth and quaking aspen (*Populus grandidentata*, *P. tremuloides*), gray, paper (white), and river birch (*Betula populifolia*, *B. papyrifera*, *B. nigra*), hawthorn (*Crataegus* spp.), larch (*Larix* spp)., all oak species (*Quercus* spp.), red alder (*Alnus rubra*), sweetgum (*Liquidambar styraciflua*), most willow species (*Salix* spp.)
Resistant[b]	American beech (*Fagus grandifolia*), black (sweet) birch (*Betula lenta*), black walnut and butternut (*Juglans nigra*, *J. cinerea*), black cherry (*Prunus serotina*), most elm species (*Ulmus* spp.), eastern hemlock (*Tsuga canadensis*), most hickory species (*Carya* spp.), red and sugar maple (*Acer rubrum*, *A. saccharum*), most pine species (*Pinus* spp.), sassafras (*Sassafras albidum*), most spruce species (*Picea* spp.)
Immune[c]	Most ash species (*Fraxinus* spp.), baldcypress (*Taxodium distichum*), yellow birch (*Betula alleghaniensis*), blackgum (*Nyssa sylvatica*), Ohio and yellow buckeye and horsechestnut (*Aesculus glabra*, *A. octandra*, *A. hippocastanum*), northern catalpa (*Catalpa speciosa*), cucumbertree and most Magnolia species (*Magnolia acuminata*, *Magnolia* spp.), eastern redcedar (*Juniperus virginiana*), balsam and Fraser fir (*Abies balsamea, A. fraseri*), American holly (*Ilex opaca*), Kentucky coffeetree (*Gymnocladus dioicus*), black locust (*Robinia pseudoacacia*), honey locust (*Gleditsia triacanthos*), silver maple (*Acer saccharinum*), sycamore (*Platanus occidentalis*), tuliptree (yellow-poplar, *Liriodendron tulipifera*)

[a] Species readily eaten by gypsy larvae during all larval stages

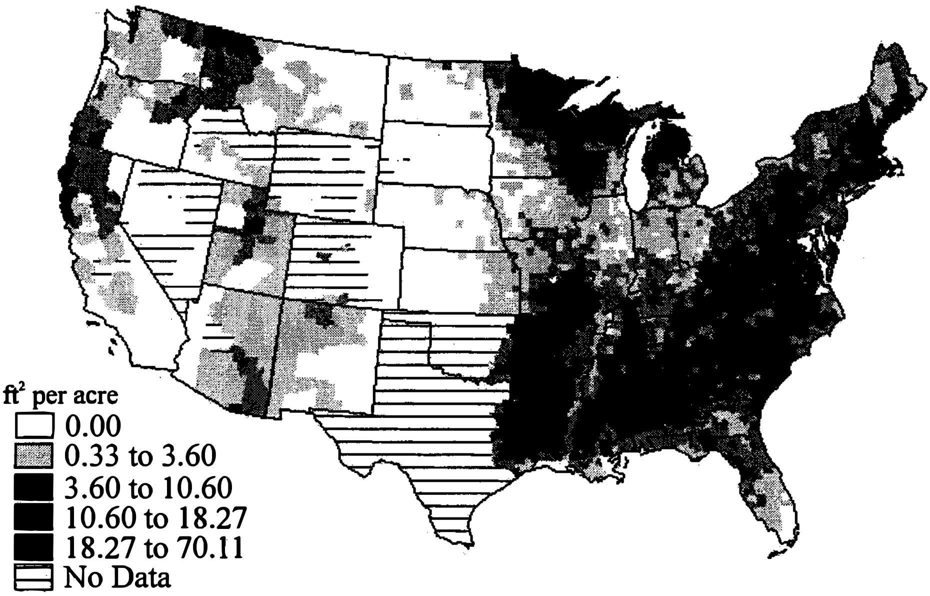
[b] Species fed upon when preferred foliage is not available and/or by some larval stages.

[c] Species rarely fed upon.

Table 2. Forest stand susceptibility to gypsy moth defoliation (Gottschalk 1993).

Percentage basal area in susceptible species	Probability of defoliation
Less than 20	Low
20 to 50	Moderate
50 to 80	High
More than 80	Very high

Figure 2. Total basal area per acre of species susceptible to gypsy moth defoliation (Liebhold et al. 1997a, 1997b). As susceptible basal area increases, the likelihood of defoliation increases.



Effects on Forests

Defoliation by gypsy moth causes a number of direct and indirect ecological and socio-economic effects on forest structure and composition and on forest values for meeting management objectives (Gottschalk et al. 1989, Gottschalk 1990). Some of the direct ecological effects include loss of acorn seed crops, increased tree mortality, reduced tree vigor and growth, increased nitrogen in forested streams, and increased water yields. Some indirect ecological effects include changes in species composition, reduced stocking, increased structural diversity, as well as increased herbaceous and understory plant growth, all of which can change wildlife habitat. Some of the socio-economic effects include reduced aesthetics, nuisance of larvae, allergic reactions to larval hairs, loss of recreation enjoyment, loss of property value, tree volume growth loss, and loss of timber values. The easiest losses to quantify have been tree mortality and timber values, and utilization of dead oak also has been quantified (Gottschalk et al. 1989). The damage to forest stands from defoliation and mortality has been termed vulnerability and has often been equated to the mortality losses. However, we prefer the broader definition of any loss of value to a management objective.

Many factors influence the mortality that occurs following gypsy moth defoliation. The most important include the amount of defoliation and the vigor, or health, of the trees before they are defoliated (Gottschalk et al. 1998). As the amount of oak in a stand increases, the amount of defoliation and mortality that occurs increases (Campbell and Sloan 1977, Davidson et al. 1999). The mortality that occurs following defoliation is quite variable—some stands may have only 5 percent mortality while other stands may have 95 percent mortality. The average mortality from gypsy moth defoliation is 20 to 35 percent depending on the amount of drought or other stresses that are present to reduce the health of the trees before or during defoliation. Only about 10 to 20 percent of the area defoliated by the gypsy moth suffers catastrophic mortality, rates of more than 50 percent of the basal area present. From 1969 to 1987, Pennsylvania had 7 million acres defoliated at least once, including 3 million acres on which mortality exceeded 20 percent and cost at $329.8 million loss of timber, averaging $107 per acre (Gottschalk 1990). The need for ways to manage forests to minimize these ecological and socio-economic effects have led to the development of silvicultural guidelines for forest stands threatened by the gypsy moth.

Gypsy Moth Integrated Pest Management (IPM)

The final gypsy moth environmental impact statement (EIS) lists three strategies for managing gypsy moth populations: suppression, eradication and STS (U.S. Department of Agriculture 1995). Suppression prevents or minimizes heavy defoliation of trees by reducing outbreak populations of the gypsy moth inside the generally infested area. Many other objectives can be satisfied using this strategy. A common one is to reduce the nuisance effect of gypsy moth larvae on people. The second strategy, eradication, prevents establishment of the gypsy moth in new areas by eliminating isolated infestations outside of the generally infested area. Artificial long-distance spread by people is the major source of isolated infestations. Eradication complements the gypsy moth regulatory program that seeks to prevent artificial spread by imposing a quarantine on the movement of articles that may contain gypsy moths from the generally infested area to the uninfested areas of the United States. The third strategy, STS, is designed to reduce the rate of spread of gypsy moth within the transition area between the generally infested and uninfested areas. Its objective is to delay the impacts and costs of gypsy moth outbreaks and management. However, the EIS did not address a fourth strategy for IPM of gypsy moth. This strategy is to manage the forest using silvicultural treatments to minimize gypsy moth effects rather than managing the insect.

Silvicultural Guidelines

A history of the development of silvicultural treatments related to gypsy moth is given by Gottschalk (1993). The first description of treatments date from 1896, and the concept of using silviculture to manage gypsy moth has been rediscovered and modified every 10 to 30 years since then. Despite this long history, there has been no research on the effectiveness of silvicultural treatments in reducing gypsy moth effects until the 1980s.

Silvicultural treatments usually are developed using one of two major philosophies: (1) focus on reducing stand susceptibility (probability of defoliation); or (2) focus on reducing stand vulnerability (probability of mortality or other effects) (Gottschalk 1989). This second approach could be described as strengthening the stand against mortality and encouraging growth after defoliation. The best approach to use varies with stand and site conditions and insect conditions. While most prescriptions are written with one approach as the objective, in many stands it may be possible to accomplish both goals with one treatment. Treatments for decreasing susceptibility eliminate gypsy moth hosts, maximize tree growth and vigor, and increase forest diversity of age classes, structures and composition. Treatments for strengthening the stand against mortality remove high-risk trees and stands, maximize tree growth and vigor, and reduce the habitat of secondary organisms that invade the defoliation-stressed trees and kill them. Decision charts that match the proper prescription to existing stand and insect population conditions are available (Gottschalk 1993). These decision charts and prescriptions are used in pre-outbreak situations in areas not yet invaded by gypsy moth or in time periods between outbreaks, in outbreak situations where defoliation is about to or already occurring, and in post-outbreak situations where defoliation and mortality have already occurred. Additional treatments have been developed that can be used to protect and maintain conifers and mixed hardwood/conifer stands by using silviculture (Gottschalk and Twery 1989).

Pre-outbreak Treatments

Reducing the amount of preferred host food in the stand reduces stand susceptibility. Changing the species composition to less than 20 percent basal area of preferred species will reduce the probability of outbreaks occurring. Treatments that accomplish this objective are "sanitation thinnings" applied as intermediate stand treatments and "sanitation conversions" applied as regeneration treatments. Both treatments convert stands that already have a mixed composition (less than 50 percent of the stand in susceptible species) to mixed hardwood stands with a lower component of oaks or other preferred species or to mixed hardwood/conifer stands with 15 to 20 percent preferred species. Sanitation thinnings can be used to reduce stand susceptibility by changing the species composition, and they can have a secondary objective of reducing mortality by removing high-risk trees and maximizing growth and vigor in the residual trees. Marking priorities are to remove oaks and other susceptible species first, followed by trees with many hiding places for larvae, followed by poor-crown trees, then by fair-crown trees. Research tests of this treatment in West Virginia were inconclusive for defoliation because gypsy moth populations were already high at the time the treatment was applied (Liebhold et al. 1998). Mortality was reduced in this treatment (from 36 to 26 percent) but was not statistically significant.

Stand vulnerability is reduced by increasing stand vigor, by removing trees most likely to die following defoliation, and by leaving trees more likely to survive defoliation. Treatments that accomplish this objective are "presalvage thinnings" applied as intermediate stand treatments and "presalvage harvests" or "presalvage shelterwoods" applied as regeneration treatments. Previous work has shown that the healthier or more vigorous the tree is when it is defoliated, the higher the probability that it will survive defoliation (Gottschalk et al. 1998). Crown condition is one of the characteristics that can be used to differentiate trees that have differing probabilities of mortality (Gottschalk and MacFarlane 1993). Removing trees that have low probabilities of survival and leaving trees with high probabilities of survival is possible in presalvage thinnings. The thinnings also increase the vigor of the residual trees further increasing their probability of survival. These treatments are especially useful in stands that have high compositions of preferred species where the susceptibility cannot be changed. Presalvage thinnings can be used to reduce susceptibility as well, but the high levels of susceptible trees present make this a minor objective. Marking priorities are to remove poor-crown oaks, poor-crown non-oak species, oaks with fair crowns, and non-oak species with fair crowns. In research plots in West Virginia, presalvage thinned stands had 40 percent mortality versus 63 percent mortality in unthinned stands. Both sets of stands had two years of heavy defoliation that occurred immediately after the thinning treatments were applied. This resulted in a worst-case scenario, as the residual stands did not have any time to increase in vigor after the treatment. The reduction in mortality was statistically significant.

Another approach to managing stands is to regenerate stands before defoliation. Young stands have lower mortality rates for the same level of defoliation as compared to that for older, mature stands. The regeneration treatments mentioned previously can preserve seed production, established advanced regeneration, and stump sprouting potential allowing these stands to be successfully regenerated before gypsy moth defoliation. This regeneration allows lower mortality when the stand is defoliated.

Outbreak Prescriptions

During and immediately before gypsy moth outbreaks, we recommend that managers do not use intermediate treatments such as thinning due to the uncertainty about which trees will die and the need for some recovery time from the thinning treatment. Managers should wait and then examine the stands for salvage treatments one to three years after defoliation. One option to protect some stands from defoliation is to spray them with a biological or chemical insecticide. There are a number of reasons for protecting stands including the maintenance of mast production; aesthetics; nuisance reduction; keeping large, high-value mature stands alive until they can be harvested; and keeping younger, high-value stands alive to maintain a percentage of green wood for mill supply. A cost-benefit analysis of spraying to protect timber value shows large benefits for stands that are close to maturity (Hicks et al. 1989). Regeneration treatments can be continued during outbreak periods.

Post-outbreak Prescriptions

Tree mortality following defoliation occurs over a number of years, but most mortality will occur in a single year usually somewhere between one and three years after defoliation. Mortality is due to the tree actually being killed by organisms other than gypsy moth that invade the weakened trees. It takes a couple of years for these organisms—the two-lined chestnut borer and shoestring root rot predominantly—to build up, invade the tree and kill it. Prescriptions such as salvage thinnings rely on efficient salvage of dead trees and thinning of live trees, salvage cuts remove dead material and leave all of the live trees for future management, and salvage harvests regenerate stands that are understocked due to excessive mortality. The degree of mortality that occurs in a stand determines which kind of salvage treatment is applied. The salvage thinning treatment provides for the increased growth and vigor of the residual trees in addition to salvaging dead trees. Utilization of dead trees is important to economical salvage. It is best to salvage within one year of death to capture the highest value for sawtimber products, but for pulpwood and firewood, longer time periods are suitable (Gottschalk et al. 1989).

Advantages and Disadvantages of Silvicultural Treatments

There are a number of advantages and disadvantages to using silviculture to manage gypsy moth effects. Disadvantages include: only a limited area can be treated per year so a long time period is needed to have a major effect on the habitat across the landscape; it cannot prevent outbreaks, only lessen their effects; and it cannot be used in areas where cutting and removal of trees cannot be done such as in wilderness areas. Advantages of silviculture include: it is usually inexpensive (i.e., done at little or no cost or a net income to land owner); it treats the cause of the problem (unhealthy, low-vigor stands) rather than the symptom (defoliation and mortality); by using hazard and risk rating, highest priority stands can be treated first to obtain the most benefit; and its use is ecologically preferable to chemical insecticides.

Summary

As gypsy moth continues to move across the eastern United States, defoliation and mortality effects on forest resources will occur in these new areas, particularly the central hardwood forests, in much the same way that northeastern forests have been affected. Management of gypsy moth utilizing IPM will provide forest managers and landowners with some degree of control over these ecological and socio-economic effects. However, central hardwood forests can benefit in advance by utilizing silvicultural treatments to create healthy, mixed stands that can survive an attack by gypsy moths and minimize its effects. Initial research results show that the use of thinning treatments can be effective in minimizing mortality following gypsy moth defoliation. It is preferable to treat stands before outbreaks to maintain stands rather than to salvage dead trees after outbreaks. Use of silviculture in managing effects of gypsy moth provides the forest manager with tools other than chemical or biological insecticides for development of integrated pest management programs for gypsy moth. Finally, it is important for managers and landowners to realize that tree species and forests will adapt to gypsy moth over time, that susceptible tree species will not disappear from the landscape and that the gypsy moth eventually will behave and interact with the forest more like native insects.

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Should Bat Conservation Issues Alone Dictate Forest Management Policy?

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Bats are an important, but poorly understood, component of forest ecosystems in central hardwood forests. Bat conservation issues recently have come to the fore in determining management direction for these forests. The occurrence of threatened and endangered bat species in central hardwood forest ecosystems has prompted concern by state and federal resource management agencies regarding the potential impacts of forest management practices on these species. This concern has led to specific consideration of bat habitat needs in long-term forest management plans. The inclusion of bat habitat requirements in management plans also has been stimulated by legal challenges by special interest groups. Most of the legal battles to date have involved the national forest system, but a private timber company recently was taken to court and state agencies are likely to face challenges in the future.

In order to develop effective management plans, managers must have knowledge of bat population parameters, life history and ecology, and habitat requirements throughout the annual cycle. They also must have the ability to monitor bat occurrence, distribution and species composition at multiple landscape scales. At present, biological, population and habitat data are incomplete for most bat species and the technology and techniques for assessing bat occurrence and distribution within forest ecosystems need further development. As a result, bat management plans that currently are in place or being developed should be regarded as "works in progress" that will be refined and improved as our knowledge base grows.

Federal forest planners are required by law to follow legally mandated procedures and include endangered species and biodiversity among the concerns addressed in forest plans. A number of lawsuits have been filed, however, that have taken biological and silvicultural decisions out of the hands of scientifically-trained biologists, foresters and planners, and placed them in the court system. Some legal challenges appear to have been mounted, not to responsibly participate in the discussion of management direction, but to advance an anti-logging agenda. These kinds of tactics tie up valuable time and resources that could be better allocated to garnering the scientific data necessary to better manage bats and forests.

Bats

Bats are a diverse and populous order of mammals. Most of the approximately 1,000 species that occur worldwide are found in the tropics. Of 148 North American bat species, 140 occur in Mexico, 45 in the U.S., and 19 in Canada (Bat Conservation International in preparation). Central hardwood forests provide habitat for 14 of the U.S. species, including 3 species that are federally listed as endangered. Although serious population declines have been noted for a number of bat species, the status of most is unknown or poorly understood because they are difficult to survey. A number of factors, including loss of old-growth forest and other anthropogenic factors, such as changes to the landscape and contaminants, are alleged to have contributed to bat population declines, but not all causal factors have been identified or substantiated (U.S. Fish and Wildlife Service 1999, O'Shea and Bogan in preparation). Even though changes in forest composition and distribution may have contributed via loss or alteration of important habitats, direct evidence is lacking.

Forests differ in structure and composition with age, location, perturbation, and management. Forests of different ages often differ with respect to stem density and openness of canopy, thus, they could differ in their suitability for bat foraging (Thomas et al. 1988, Crampton and Barclay 1996). Forest age also could influence bat roosting opportunity as a consequence of differences/changes in the number of trees of appropriate size and decay, and the number with cavities or other shelter (Mannan et al. 1980, Rosenberg et al. 1989, Newton 1994). Bats may prefer older forests to younger ones (Perkins and Cross 1988, Thomas 1988). Disturbances and management within forests can affect bat habitat by creating openings for foraging but also can remove potential roost trees (Crome and Richards 1988, Krusic and Neefus 1996, Crampton and Barclay 1996). The effects of major activities such as commercial harvest are two fold. The creation of openings and edge can increase foraging habitat, but the removal of roost trees and the truncation of the age distribution of trees within the forest could affect bats negatively (Crampton and Barclay 1996).

Managing for the entire bat community creates additional challenges for planners and managers. The differing life histories of forest inhabiting bat species pose planning problems and have implications for both management and monitoring. For example, some species of bats are colonial and are concentrated in certain areas but are absent from others. Other bats are widely dispersed and may be "common" everywhere but not be numerous anywhere (O'Shea and Bogan in preparation). Additionally, some essential bat resources (e.g., caves, streams) are in fixed locations on the landscape and, therefore, must be managed only at specific sites, whereas others (e.g., roosts, foraging habitat) are ephemeral and must be managed for sustained availability through time.

Land managers also face problems associated with determining bat occurrence at a site and monitoring them at known locations. To rectify these problems, accepted methodologies for inventory and monitoring of bats (e.g., mist netting, roost counts, echolocation surveys) are urgently needed (O'Shea and Bogan in preparation). Assessment of habitat quality on the basis of bat survey data is further complicated by population declines. As a consequence of diminished populations, a lack of occurrence may reflect a shortage of individuals to exploit a site rather than a deficiency in the habitat quality of the site.

Few empirical data are available regarding the effects of habitat management on bat populations. The studies that have been conducted on bats have largely focused on life history, ecology or habitat associations. Comparatively few studies have examined responses to habitat manipulation. Thus, investigations into the effects of habitat management on bat populations are acutely needed. Endangered bat species have been studied more extensively than other bats and as a result, more is known about them. For example, the Indiana bat is arguably one of the most-studied bats in the eastern U.S., and managers have access to a considerable amount of information relating to both its life history and habitat requirements. Despite this knowledge base, additional studies directed specifically at the response of this species to forest manipulation would greatly enhance the ability of managers to predict the effects of their management prescriptions. For some bat species, even basic information such as presence/absence in an area, ecology, and life history is unknown and consequently may have to be inferred from knowledge about other species. Predicting the effects of management on these less-studied members of the bat community thus presents an even more formidable challenge. Our lack of knowledge can be and has been exploited by opponents to forest management. Managers are being asked to defend their management policies and practices during legal challenges, but often lack the definitive data necessary to counter charges by opponents.

Legal Background

When Congress first established the predecessors of today's national forests, prior to the 1900s, legislators were largely concerned with protecting two basic raw materials—timber and water. The Forest Service's mandate for management began changing in 1960, and now is regulated by a complex array of statutes. Currently, the overall mandate in the law can be characterized as the conservation of biological diversity, but this mandate has evolved over time (Norse et al. 1986).

The Multiple Use Sustained Yield Act of 1960 instructed the USDA Forest Service to manage forests for multiple uses—outdoor recreation, range, timber, watersheds, wildlife, and fish. The adoption of other acts in the 1960s and early 1970s, including the Wilderness Act, the Wild and Scenic Rivers Act, and the Clean Water Act, recognized the legitimate use of national forest lands for additional ecological values. The National Environmental Policy Act (NEPA), enacted in 1969, made the protection of environmental quality a goal of every federal agency. Under NEPA, the Forest Service must prepare Environmental Impact Statements (EIS) to disclose fully the environmental effects of proposed actions. The Endangered Species Act (ESA), of 1973, as amended, prohibits federal agencies from taking any action that could jeopardize the continued existence of designated species or destroy or adversely modify their critical habitat. As a consequence of the ESA, agencies must consult with the Fish and Wildlife Service (FWS) and prepare biological evaluations/assessments about the possible effects of their actions on listed species (Norse et al. 1986).

Two acts in particular gave the Forest Service direction in planning for resource management on National Forest lands. The Resource Planning Act (RPA) of 1974 was the first law to call for nationwide planning by the Forest Service. It required the Forest Service to undertake two kinds of national planning: an assessment of the nation's renewable resources and the demand for them, and a Renewable Resource Program to set national goals for outputs from the National Forests. The 1976 National Forest Management Act (NFMA) requires the Forest Service to translate the national goals of the Renewable Resource Program into goals and plans for individual units of the National Forest system (Norse et al. 1986).

Thus the law does not merely prescribe procedures for planning, it sets substantive standards that plans must meet, including standards for conserving biological diversity. Many of these standards are contained in the NFMA and its regulations, but others are scattered in federal laws, in the ESA, the Wilderness Act, the Wild and Scenic Rivers Act, the Clean Water Act, and other acts and regulations. The Forest Service's central planning regulations under NFMA require the Forest Service to manage the land so as not to impair its multiple-use productivity, and to consider, protect and, where appropriate, improve the quality of renewable resources. The Forest Service's fish and wildlife regulation requires that habitats be managed to maintain viable populations of existing native and desirable non-native species. Forest plans must give special consideration to the habitat of threatened or endangered species. The Forest Service's diversity regulation requires planners to provide for diversity of plant and animal communities consistent with the overall multiple-use objectives of the planning area, to consider past as well as present diversity, and to weigh how each alternative would affect diversity (Norse et al. 1986).

Forest Management Planning

Forest Service planning takes place on three levels — national, regional and local. The RPA program of national goals for timber, grazing, wildlife, recreation, and watersheds was divided into regional guides. These in turn were followed by individual national forest plans. Site-specific decisions (plans) then are made for small areas such as timber sales, wildlife activities or recreation projects on forest districts (Norse et al. 1986, G. Houf personal communication: 2000).

To prepare a forest plan, issues and concerns are identified, and criteria and constraints that govern the planners' choices are formulated. Data are gathered on the forest resources and the ability of the forest to supply resource outputs is analyzed. The planners suggest a range of alternative management schemes to meet the goals set for the forest in the regional guide. Planners attempt to estimate the effects of each alternative on the environment and on resource supply. Applying criteria set forth early in the planning process, the forest supervisor selects a preferred alternative. The planning horizon is 50 years, and plans are revised every 10 to 15 years. The Forest Service prepares an EIS for each proposed plan (Norse et al. 1986).

Both the NFMA and the NEPA require the Forest Service to offer opportunities for public participation in the planning process. Typically, this is done from the beginning of the process when the public is invited to help identify issues and concerns relating to forest plans through various public forums or written comment. The public also can comment on EISs. After a plan has been approved, citizens still have an opportunity to change it through an administrative appeal. Decisions on forest plans are appealed to the Chief of the Forest Service. After the Chief rules on an appeal, the Secretary of Agriculture has the option of reviewing the Chief's decision. Finally, citizens affected by the plan can seek review in the courts (Norse et al. 1986).

Much of the current situation revolves around endangered species issues. Although the Forest Service has prepared land and resource management plans for its various national forests under NFMA and NEPA, endangered species concerns have provided fertile ground for litigation by Forest Service opponents. If endangered species are not handled correctly in the planning process and in appropriate consultation with the FWS, activities on entire national forests can be impeded and their planning processes can be set back by requiring additional NEPA- and ESA-mandated reviews.

Special Interests

Environmentalist groups and private citizens in a number of states have actively opposed the management policies, plans and practices of the Forest Service. One of these groups has the stated goal of stopping all timber harvest on public land, as evidenced by the motto prominently portrayed on their website: "Together, We Can End Logging on Our National Forests." Such a goal negates harvest prescriptions as a forest management tool under any circumstances. While espousing concern for endangered and other forest species, there is no apparent regard for the legitimacy of forest uses beyond the group's own narrow objective. Suits have been filed against the following national forests: Allegheny in Pennsylvania, Wayne in Ohio, Hoosier in Indiana, Shawnee in Illinois, Mark Twain in Missouri, Daniel Boone in Kentucky, and Monongahela in West Virginia. Of the suits that have been decided, the plaintiffs have lost only one.

National forests have been attacked at all levels in the NEPA process, from the programmatic level to the prescription level. Most of the suits have claimed that the Forest Service failed to follow planning procedures prescribed by law and regulation, or violated the ESA, particularly with regard to the issue of incidental take (take of an endangered species that results from, but is not the purpose of, carrying out an otherwise lawful activity). The plaintiffs have been very skillful in demonstrating that the defendants did not follow all of the procedural steps necessary for plans, amendments or projects to proceed. National forests have even been attacked and penalized when they have attempted to document the occurrence of Indiana bats on national forest lands and incorporate bat habitat requirements into management plans. These court cases usually involve an injunction against any on-the-ground activities during the review or consultation process, and have the effect of inhibiting activities on national forests for extended periods of time.

Another issue looms on the horizon for which federal agencies should be prepared. Under the ESA, federal agencies also are to actively carry out programs for the conservation of endangered species, in consultation with the Fish and Wildlife Service. This provision of the ESA has been neglected by some agencies for years (P. McKenzie personal communication: 2000). It is possible that after litigation concerning NFMA- and NEPA-mandated planning has run its course, special interests will seize upon this provision of the ESA to mount a new set of legal challenges.

While federal agencies clearly must be concerned about opposition from special interest groups, state agencies and private firms and individuals should be aware that they also may be targeted in the near future. Most legal actions to date have focused on the Forest Service, but a recent suit against a private firm in West Virginia and public statements to the press show that forest management on state and private lands will be challenged, as well.

Endangered Species

The Indiana bat (*Myotis sodalis*), an endangered species, has become a focal point for special interest groups in challenging forest management in the central hardwood region. During the past 20 years, the Indiana bat population has declined precipitously and continues to decrease in parts of its range (U.S. Fish and Wildlife Service 1999). Unfortunately, experts are not in full agreement on the factors that limit Indiana bat populations or that have contributed to their decline. As a result of our incomplete knowledge of the life history and ecology of the Indiana bat, there is no universally accepted set of standards and guidelines available for agencies to use when formulating management plans. Further exacerbating the problem is a lack of consistency regarding recommended habitat management prescriptions and limitations by the Fish and Wildlife Service when writing biological opinions in different portions of the range of the Indiana bat.

Conclusions and Recommendations

As a consequence of statutory mandates and legal challenges, agencies are being forced to make decisions that have long-term implications, but the effects of those decisions are not fully understood or debated. The conflicting nature of the mandates (single species/endangered species versus multi-species/multi-use) poses an important dilemma, and perhaps an intractable one in the current climate. Some of the legal challenges brought against agencies, however, may have been beneficial to the extent that they have encouraged federal agencies to closely examine their policies, procedures and plans to determine whether they are in compliance with legal mandates and are serving the needs of the resources and the public.

Although bat conservation issues are unquestionably important and legitimate components of forest management planning, they must be considered in the context of the needs of other biota and forest uses and not to their exclusion. The current situation is potentially unbalanced because single species (i.e., endangered species) issues are driving the system. As detailed earlier, public resource management agencies have other mandates that cannot be ignored. Focusing solely on one species or group can lead to the degradation of other resources and the likelihood that other interest groups will become vocal and adversarial. Conflicting mandates make it difficult for forest managers to balance their programs and leave them open to challenge irrespective of the management alternative that is chosen.

Bats of the central hardwoods evolved under a very different regime of habitat distribution and perturbation than that which exists today. Historic anthropogenic activities have altered forest ecosystems to such an extent that few present communities are likely to be functionally analogous to the communities that existed 100 or 200 or more years ago. The limited extent of public ownership in the central hardwoods region and the uncertainty of naturally occurring events that would reproduce the full range of conditions needed by the entire spectrum of bats on this limited land area argues for active rather than passive management. Furthermore, naturally occurring events and processes, while they do operate on private ownerships, cannot be relied upon to produce desired end results. Therefore, active, planned forest management on public lands would seem to have the highest probability of providing the needed range of habitat conditions, widely distributed on the landscape.

Knowledge Acquisition

Additional research on the ecology, population dynamics and habitat requirements of central hardwood forest bats is in critical need. Refinement of techniques and appropriate sampling protocols for monitoring bat distribution and occurrence by species is an important first step (O'Shea and Bogan in preparation). If such methodologies cannot be developed and adopted, it will be difficult to proceed with management or research.

There is a general understanding of how bats use forests, but studies are needed on how specific management activities affect bats. Additional research as suggested by Bat Conservation International (in preparation) is needed to:

- quantify roosting and foraging requirements of different species of bats;.
- determine the best mixes of roosting and foraging habitats for different bat species;

- evaluate the effects of evenaged and unevenaged treatments on different bat species;
- quantify the effects of cultural treatments on bat occurrence, roosting and foraging;
- investigate the effectiveness of actively creating tree roosts; and
- investigate the effectiveness of artificial roosts.

The following studies are examples of the types of research that are needed: Krusic and Neefus (1996) in the White Mountains of New Hampshire; Thomas (1988) and Erickson and West (1996) in the western Cascades, Crampton and Barclay (1996) in Alberta, Grindal (1996) and Perdue and Steventon (1996) in British Columbia, and Parker et al. (1996) in Alaska.

Management

Although endangered species and timber harvest are legitimate outputs from the forest, all legitimate uses and species should be accommodated. The forest must be managed as a complete, functioning ecosystem if it is to accommodate the full range habitat needs and tolerances of the animals, including bats, that evolved within the central hardwood forest. Management for one seral stage or structure would necessarily favor one group of species over others. Managing for all species will take forethought and planning, but is the only way to fulfill the obligation to preserve biodiversity. Habitat manipulation increasingly must serve multiple purposes. Managers therefore must become more creative in the application of timber harvest to meet other goals and uses. The challenge will be to coordinate and balance the full array of interests.

Without question, bats should be included in forest management planning. Managers and planners must do the best they can, given the current state of knowledge, and strive to improve as new knowledge is acquired. An adaptive management approach (*see* Johnson 1999) would be best, because of time constraints and because decisions cannot be delayed until some unknown time in the future. Coordination and information exchange among land managers and researchers would greatly facilitate the advancement of knowledge, especially if management experiments are conducted in multiple regions of the forest.

Different management approaches may be required on different landscapes. For instance, much of the land in the primary Indiana bat summer breeding range is privately owned. In contrast, a higher proportion of the land in the vicinity of Indiana bat hibernation caves is under public ownership by state and federal agencies. Thus, to protect and preserve vital habitats that are needed throughout the annual cycle, it is important that a comprehensive program of Indiana bat habitat management be developed. Ideally, outreach programs would be designed to encourage private landowners to address bat habitat requirements in the primary summer breeding range and agencies would focus their management efforts on public lands in regions surrounding hibernacula. Only in this manner will the seasonal and rangewide needs of a species such as the Indiana bat be addressed fully.

Forest management can benefit bats if it includes prescriptions that will maintain or recruit roost trees and improve foraging habitat. Such practices should increase vegetative diversity, promote smaller cuts, retain tracts of mature and old growth forest, provide travel corridors, incorporate sensitive habitat buffer zones, and retain wildlife trees (Bat Conservation International in preparation). The ability of bats to use different structures and habitat types depends upon their mechanical and perceptual adaptations (Fenton 1990, Bradshaw 1996). A mosaic of habitats encourages bat use and species diversity (Krusic and Neefus 1996). Spatial patterns and corridors are important considerations in designing landscapes for bats (Thomas 1988, Erickson and West 1996, Crampton and Barclay 1996, Grindal 1996). At this time, it appears that providing a range of habitat conditions has the highest probability of accommodating the needs of the full array of bat species. Managers should strive to take a proactive approach and design actions for bats rather than constantly being on the defensive.

Cave roosts used by endangered bats for hibernation and those used during summer should be protected from human intrusion during the period of September 1 through April 30 and April 1 through September 30, respectively. Corridors consisting of contiguous tree canopies should be maintained between cave roosts and foraging areas (U.S. Fish and Wildlife Service 1983, 1999). Managers should manage for a mixed-age forest with a multi-level canopy. Patches of mature forest should be connected with travel corridors. Snags and den trees should be maintained in timber sale sites and in cultural treatments. Riparian zones should be maintained or restored to forest corridors. Water quality in streams, rivers, and lakes should be enhanced (Thomas 1988, Krusic and Neefus 1996, Erickson and West 1996, Crampton and Barclay 1996, Grindal 1996). Several national forests and state agencies have adopted habitat management guidelines specifically designed for the Indiana bat, including the Daniel Boone National Forest in Kentucky, the Hoosier National Forest in Indiana, the Missouri Department of Conservation, and the Ohio Department of Natural Resources. We recommend that readers obtain these detailed guidelines and adapt the principles they contain to their own particular regions and forests.

Planning

Managers and planners must work with interested, responsible private groups and citizens in forest management planning. The private sector must be invited in and involved early in the process so that they will understand and support the final product(s). Their aid and involvement should be enlisted in debates and court cases related to management direction. Scientifically sound management and biological information should be provided to journalists so that the public is informed and can participate in the debate. Threats posed by special interests with single issue agendas should be taken seriously. When these groups attempt to subvert the process, they should be opposed vigorously, with logical and appropriate arguments.

The Fish and Wildlife Service policy regarding habitat management in biological opinions should be consistent throughout the range of the Indiana bat. Specified "terms and conditions" and "reasonable and prudent measures" should be based on the best scientific information currently available that is applicable to the region of concern, and updated as new information is generated.

It is incumbent upon federal agencies, particularly the Forest Service and the Fish and Wildlife Service, to work together in planning and managing for endangered species. The Forest Service must engage the Fish and Wildlife Service in consultation at the appropriate times in the planning and implementation process. Outside interests are closely following each federal agency's actions. The special interests are well organized and communicate through a variety of networks. Issues and strategies that work in one region are likely to be rapidly employed in other regions. In order to minimize the potential for disruptive lawsuits, federal agencies must follow both the letter and the spirit of the law when performing all prescribed procedures.

Lawmakers should examine the full complement of laws that dictate forest management planning and implementation, and consider amendments that will promote the resolution of conflicting mandates. If successful, this effort would reduce the likelihood that special interest groups would be successful in thwarting legitimate resource management activities of state and federal agencies via frivolous legal challenges.

Responsible land managers have no choice but to make decisions based on the current state of knowledge, recognizing that present knowledge is imperfect but improving. Ultimately, forest management mandates provide the guidance that should be heeded: land managers must manage, to the best of their ability, for the full array of species and uses appropriate to the land. Such a policy is the best hope to ensure that biodiversity will be preserved in the future.

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The Challenges and Opportunities of Restoring Ecosystems in Urban-influenced Areas: Insights from Northeastern Illinois

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As the population of the United States increases and new development sprawls out across the landscape, ecosystems are greatly impacted. Sprawl and the competition for undeveloped land outside urban areas makes it especially important that we make the most effective use of the existing bank of reserved open space. Meeting goals of ecological health and connectivity at the same time that undeveloped lands are being converted to urban areas means that we have to pay closer attention to the integrity of natural areas within the urban system. Restoration is one of the best means that we have for accomplishing these important goals. The practices of "healing" degraded ecosystems through ecological restoration are becoming more effective with advances in scientific knowledge of how ecosystems function, as well as more practical experience in restoring ecosystems.

Taking only biological and ecological factors into account, the means for restoration in the face of sprawl may be relatively simple—set aside more land, restore already preserved lands to more pristine conditions, and minimize human impacts. However, biological and ecological systems cannot be isolated from the human context in which they exist, which is why the restoration process is far from simple. As people and associated developments expand into the landscape, the ecosystems change, and so does the social context in which they exist. These physical, biological and social changes have important implications for the way that we plan and carry out resource management. What has been happening with the restoration movement in northeastern Illinois is a good example of how the challenges of restoring ecosystems in urban influenced areas may be turned into opportunities for peaceful coexistence between large human populations and healthy ecosystems.

The Situation in Northeastern Illinois

Northeastern Illinois is a diverse landscape that owes a great deal of its character to the Wisconsin glacier that covered much of Illinois and receded only 13,000 years ago (Chicago Wilderness 1999a). In its wake it left Lake Michigan, rich prairie lands, dunes, forests, woodlands, and wetlands. The large lake and associated system of waterways formed an excellent base for a transportation hub for the developing nation.

Beginning in the 1830s, the landscape was manipulated and changed in the name of progress. The wetlands were drained and the prairies plowed for farmland. The woodlands were cut to provide fuel and building materials. The dunes were flattened, railroads were built and steel mills established. An industrial hub of Chicago, Nature's Metropolis, was born (Cronon 1991). Despite the rapid pace and large scale of development, early planners had the foresight to set aside areas as forest preserves. Legislation establishing the Forest Preserve District in Cook County, Illinois was enacted in 1913 (Wendling et al. 1981). Forest preserve or conservation districts were subsequently established in the other counties in northeastern Illinois. In other instances, just by chance in some cases, small pockets of natural areas were left relatively undisturbed throughout northeastern Illinois.

The population of the city of Chicago peaked in the 1950s at about 3 million. Although the city's population is 2.8 million today, the population of surrounding areas has dramatically increased, and the Chicago region now includes more than 8.5 million people. Not only are populations increasing, but of even greater consequence for ecosystems, people are spreading out across the landscape. In northeastern Illinois, it is projected that over the next 10 years, developed land area will increase at more than twice the rate of population growth (Openlands Project 1999). This phenomenon, often referred to as sprawl, makes issues related to the preservation and restoration of natural areas near urban centers especially urgent.

In this paper, we use northeastern Illinois to illustrate the intricacies of relationships between people and ecosystems in our modern urbanizing world. Issues similar to the ones we highlight here are being faced in places across the country and the globe. The purpose of this paper is to share what has been learned in northeastern Illinois so that it can inform resource management elsewhere. The discussion begins with the growth and development of ecological restoration and provides brief descriptions of restoration efforts from northeastern Illinois. Next, challenges that have emerged in carrying out restoration are discussed. The final sections present lessons learned from addressing the challenges and future implications for restoration in northeastern Illinois and beyond.

New Insights and Knowledge

With expanding experience from hands-on practice and conduits for sharing information, such as the journal *Restoration Ecology* (formerly *Restoration and Management Notes*), the field of restoration ecology has come a long way in the last few decades. Many of these advances have taken place through the work of volunteers and scientists in northeastern Illinois (Stevens 1995). Goals of these restoration efforts include bringing presettlement vegetation back to the landscape, restoring ecological processes, creating wildlife corridors, and improving habitat for migratory birds and native fauna.

Along with these advances in the practice of ecological restoration, a broader landscape view of the management of natural systems has emerged. Although the increasingly popular labels landscape ecology, ecosystem management and sustainable development vary in nuance, their overall goals are similar. The trend is toward holistic management across the landscape with an aim of sustaining ecosystems.

Opportunities for such holistic management often are discussed in terms of large areas of lands that are protected—such as national forests and national parks, and more locally in extensive forest preserves—but they do not need to be limited to these areas. There also are exciting opportunities for ecological restoration and improvement of habitat on the fringes and even in the middle of urban areas.

In northeastern Illinois, areas that have the potential to serve as important sites for ecological restoration include forest preserves, city parks, former industrial sites, urban river corridors, and railroad rights-of-way. Restoration in each of these circumstances is outlined below.

The Restoration of Forest Preserves

Joseph Nevius, General Superintendent of the Forest Preserve District of Cook County identified three eras of the development of the Cook County Forest Preserve system (Stewart 1995). In the first era, from the 1920s through the 1950s, the emphasis was on land acquisition. From the 1950s through the 1980s (the second era), more effort was put into developing and constructing facilities. Today, the Forest Preserve District of Cook County has holdings exceeding 68,000 acres. However, since the time of acquisition little ecological maintenance has occurred on these lands. Isolated from ecological processes such as fire, lands on the preserve have been overtaken by exotic species that out-compete native tree seedlings and understory plants. The current era, beginning in the 1990s, is the era of restoration of both natural and built features in the Cook County Forest Preserve system. Restoration also has become an important component of the activities of other forest preserve and conservation districts in northeastern Illinois.

The Rehabilitation of Lakefront Parks

Early planners also saved Chicago's lakefront from development (Wille 1972). However, a great deal of manipulation has occurred, and in the extreme case this has consisted of creating lands where they did not previously exist by using fill excavated from subway tunnels. These lakefront parks for the most part exhibit the well-manicured and designed character of many urban parks. However there are places that by chance have evolved into wilder places that serve a number of ecological functions. For example, Montrose Point in Lincoln Park has become an important stopover for migrating birds (Gobster and Barro in press). Major efforts are underway to restore this area as well as other sites in Chicago lakefront and neighborhood parks.

Reclamation of Former Industrial Sites

The Lake Calumet area on the southeast side of Chicago was once the hub of a booming steel industry. Lake Calumet, originally an expansive natural lake and wetland, was dredged to allow passage of larger ship traffic and filled in on its edges for waste management. Nevertheless, unique natural resources remain throughout the Calumet area. The area is still the site of several large landfills, but things in the Calumet area are changing. The city is not allowing new landfills, existing landfills are being capped, and the opportunity has arrived to highlight the area's more natural setting and restore some of its natural splendor. The City of Chicago's Department of the Environment and Department of Planning and Development are working on plans for rehabilitating this area. A number of public agencies, private firms and local groups are eager to become involved with the restoration process in the Calumet area.

Chicago River

The Chicago River has undergone several transformations since the early settlement days when it was a wide river that meandered through prairies, savannas and the new settlement of Chicago (Gobster and Westphal 1998). The river was channeled for flood control and, in 1900, the flow of the river was reversed to reduce contamination of Lake Michigan. For many years the Chicago River was perceived as more a detriment than an asset to the Chicago area; but clean water initiatives in the 1970s began to bring improvements in water quality. In the late 1970s, a group of concerned citizens formed "Friends of the Chicago River." It's goals were to protect and improve the environmental quality of the Chicago River and its related waterways, encourage appropriate economic activity and development that are sensitive to the environment, and increase awareness, involvement and appreciation of the river by the public and policy makers. Since the late 1970s, the quality of the water in the river has increased dramatically. In addition, the river is the site of increased levels of water-based recreation such as canoeing and kayaking, and in some places even fishing. Ecological restoration activities are underway in some areas of the Chicago River corridor and many more are planned.

Rails-to-trails

In its early days Chicago was the hub of commerce for the industrializing nation. The railroads fanned out in all directions across the landscape. With the advent of the interstate highway system in the late 1950s and expansion of the trucking industry, the railroads decreased in importance and many of the rail lines were abandoned. They have been rediscovered by recreationists and conservationists. Not only are the abandoned rights-of-way being adapted for bicycle trails; but, because they were set aside for all those years, they are now serving as a source of seeds and plants of species that have disappeared or been out-competed in other more heavily manipulated areas. Former railroad rights-of-way are an important component of Chicago area's greenways and figure prominently in future greenway development and enhancement efforts (Northeastern Illinois Planning Commission and Openlands Project 1992).

Challenges for Attaining Restoration Goals

Many opportunities exist for improving natural areas within urban and urbanizing areas and linking these areas with natural areas in less developed settings by establishing corridors that facilitate the movement of wildlife and people across the urban system. At the same time, there are numerous challenges to these efforts (Gobster 1997, Ross 1997, Shore 1997). The experience in northeastern Illinois suggests that these challenges are not insurmountable, but they do need to be addressed in order for ecological restoration programs to receive the public support that is essential to their success. In some instances these challenges and the resulting responses have had the end result of strengthening the restoration movement.

The challenges to ecological restoration can be categorized into four areas: land ownership/jurisdiction; perceptions of species; implementation; and different types of knowledge. Each of the four challenges will be discussed briefly using illustrations from events in northeastern Illinois in recent years.

Land Ownership/Jurisdictions

Since natural resources do not adhere to jurisdictional boundaries, land ownership can become a challenge for ecological restoration. When there are areas of adjacent lands managed by different groups, conflicts can arise. For example, while the Forest Preserve District of Cook County designates 80 percent of its land for preservation and 20 percent for recreation, an adjacent city park may have recreation and esthetics as a priority, or a nearby private landowner may make entirely different management objectives. These differences who has it difficult to manage critical habitats across the landscape. These challenges are increasing as urbanization brings increased fragmentation of ownership across the landscape. Collaborative stewardship efforts such as those underway under Chicago Wilderness (1999b) offer promise for improved linkages in management across land ownerships.

Another way jurisdictions can come into play is within the same agency or organization where different groups support different priorities for management. This can be illustrated by what has occurred during the planning for the future of Montrose Point in Chicago's Lincoln Park. People with different backgrounds and responsibilities within the Chicago Park District diverged in their views of what this area ought to be in the future. Most of these differences centered around the many roles that Montrose Point could play for park users. The desirability of adhering to the original landscape plan for the area was a particularly difficult issue (Gobster and Barro in press).

A less traditional way that jurisdiction has come into play is when different groups who may not technically have jurisdiction assume stewardship of an area. This has been the case with lands managed by the Forest Preserve District of Cook County. For more than 30 years volunteer restorationists have been working on restoration of some prairie and savanna sites on District lands. After some time these individuals and groups become personally attached to these areas and their management (Ross 1994, Stevens 1995, Schroeder in press,). The issue of the responsibilities of volunteers on public lands in the Chicago area came to a head in the autumn of 1996 when residents living near one of the restoration sites objected to the restoration activities that were taking place. One key point of concern among residents was what appeared to be "unsupervised volunteers" who were private citizens or members of not-for-profit groups manipulating the vegetation on public lands. The issue of who was in control of restoration activities on public lands — volunteers or the managing agency — came to be one of the central factors in the restoration controversy (Gobster 1997).

Perceptions of Species

Plant and animal species are viewed in different ways by different people, which provides a challenge to those interested in conducting ecological restoration. While biologists and ecologists may view animals as part of a population, the general public may see animals as individuals and even attribute human characteristics to them. What a biologist sees as culling a herd for the good of the population may be murder to an animal rights activist. Animal rights activists have played a very active role in the restoration controversy, particularly with respect to the desirability of reducing deer populations.

New issues are introduced when including the differences in the role or function of plants to different groups of people. While a restoration ecologist may see the plant as a component of an ecosystem that complements other species and is part of a natural mix suited to the site, others may see its role quite differently. One plant prevalent in the Midwest and reviled by ecologists as a competitive exotic invasive is European buckthorn, which shades out native understory plants. However, homeowners value the species for its attributes as a living fence and visual barrier (Gobster in press). Utility and transportation agencies may plant buckthorn to screen trains and relay stations. Birders may value buckthorn for providing midlevel canopy structure, bird habitat and food, and improved opportunities for viewing.

Trees often have high values to urban residents for a wide range of purposes (Dwyer et al. 1992). However, some efforts to restore prairie, savanna and woodland environments may involve the removal of trees that are not thought to have been part of the presettlement vegetation on those sites. Tree removal in these situations can generate significant controversy among those who place high values on urban trees.

Implementation

The means used to restore "degraded" ecosystems to more natural conditions are not always gentle. For example, to remove buckthorn successfully requires cutting, followed by direct application of herbicides on the stumps and then by prescribed burning. This does not occur just once but must be continued for a number of years until a competitive advantage is gained by native species, and even then constant vigilance may be required. Consequently this disruption of plant communities can continue for an extended period of time. Objections to management practices such as removal of trees and brush, applying herbicides, burning, and removal of deer emerged as important concerns in the restoration controversy (Gobster 1997).

Several process- and context-related issues concerning the implementation of restoration also emerged during the controversy (Gobster 1997). These included a perceived lack of public information on planned and ongoing restoration activities, insufficient opportunity to participate in restoration planning, lack of written plans and a well-defined planning process for restoration, and questions concerning who was in charge of planning and carrying out restoration activities—the public agency or the volunteers.

Different Types of Knowledge

Another important dimension of the controversy over ecological restoration in the forest preserves is the validity of different types of knowledge about ecosystems and their management. Scientific knowledge has been cited by restorationists as the authority for their efforts. Helford (in press) found that residents living near the forest preserves had a different type of knowledge about the sites. They sometimes disagreed with the scientists cited by the restorationists. These residents also sometimes worked with other scientists who held different views of ecosystem restoration.

There are a number of reasons why knowledge has been a particularly significant issue in the restoration controversy: (1) the exceptional complexity of the ecosystems in question that are being worked with, (2) limited research on these systems and how they are likely to respond to management, and (3) the significant amount and wide range of intimate experiences that restoration volunteers and local residents have with the sites where restoration is taking place. Given the high level of disagreement concerning these ecosystems and how they are likely to respond to management, Cook County officials formed an advisory board that included citizens from around the county to guide restoration activities. The scientific leanings and backgrounds of those on the advisory board emerged in heated debates during panel deliberations. Knowledge is likely to remain an issue in the restoration controversy for some time. There is still much to be learned about ecological restoration, including the long-term outcomes of management practices and the acceptability of these practices to nearby residents, other site users and the public.

What We Have Learned: Building on Opportunities

Although challenges to ecological restoration in northeastern Illinois continue, they have brought many lessons and new opportunities for improving restoration activities.

Listening

By listening to the many views of those concerned with ecological restoration, managers can develop better, stronger plans that have a greater level of support from the public.

Clear and Logical Plans

Among the most important lessons learned from the northeastern Illinois experience is the need for management agencies to have a clear and logical plan. One of the factors that seemed to alarm citizens most about ecological restoration taking place in the forest preserves was the apparent lack of an overall plan. Time and again, citizens asked if such a plan existed. It seemed that citizens were not necessarily always questioning the expertise of those responsible for the restoration activities. Instead, they just wanted to know that it had been thought through and that the outcome would not be a surprise.

This desire to see and know that there was an overall plan came up in another recent study where we were investigating public perceptions of potential control strategies for an exotic invasive, the Asian longhorned beetle. Residents of one of the neighborhoods hardest hit by the infestation wanted not only to know the eradication plan, but they also wanted to see the plan for replanting the neighborhood after infested trees had been removed. Participants in that study stressed the need for a plan and sound justification for it, especially when the situation was changing.

Relevant Information and Communication

Sound, relevant information and communication between the public and resource managers are also critical. Parties to a controversy need to be open to listening and realize that there are strongly held positions on all sides of an argument. It is helpful if people are willing to listen and learn, and reach a judgment about the position of those they disagree with based on a fuller understanding of their position, rather than based on selective sound bites.

Recognize More Than One Public

Managers also need to recognize that there may be more than one "public," and that these different publics may have different concerns and values regarding natural environments. In fact, considerable diversity of viewpoints can exist within a single interest group or organization. Public involvement should occur early in the process of planning for restoration of an area or responding to a "natural disaster" such as the infestation of neighborhood trees by the Asian longhorned beetle. Early public involvement paid huge dividends in planning for the restoration of the Chicago River and its corridor as well as Chicago's Lincoln Park (Gobster and Westphal 1998, Chicago Park District and the Lincoln Park Steering Committee 1995). In the matter of ecological restoration, experts need to recognize that there is a generally low level of technical understanding among the public concerning biodiversity, ecological processes and ecological restoration (Barro and Bopp 1999, Barro and Bright 1998). This is not to say that the public cannot help guide the planning process. In fact, many members of the public are very insightful, eager to learn and become involved in planning and can contribute greatly to developing a plan that will receive widespread public approval.

Use Collaborative Approaches and Demonstration Projects

Chicago Wilderness (CW) is a consortium of nature-based organizations that have joined together to foster support for preservation and restoration of natural areas in the region. CW has spent a lot of energy thinking about means and opportunities for improving communication about these complex issues. From their efforts we learn the value of presenting a coordinated and reinforcing message from the host of organizations that speak about the natural environment. Demonstration projects where people can see first-hand the processes and outcomes have proven to be effective tools in starting dialogues with people. Examples include The Grove, Swallow Cliff and Midewin National Tallgrass Prairie. The Biodiversity Recovery Plan (Chicago Wilderness 1999b) provides a great deal of information on ecological restoration in northeastern Illinois and communicating about it with the public.

Tap Into Groups That Already Exist

Tapping into groups that already exist and have activities centered on the natural world is another way to improve communication. These groups include Audubon, Sierra Club, Nature Conservancy, tree care volunteers (such as the group Treekeepers in the Chicago area), and the Volunteer Stewardship Network in Illinois. These people are generally local and can help to bridge the gaps between scientists, managers and citizens. However, in developing working relationships with such groups, it should be recognized that each group has a particular interest in and perspective on the natural environment and its management and use that may emerge in the group's communications with others.

Be Willing to Compromise

The willingness and ability to compromise is critical for a mutually acceptable plan to go forth. This doesn't necessarily mean that everyone loses. Gobster and Barro (in press) talk about participative planning and how a third party can help to negotiate a conclusion. Examples of compromises that can be effective include, for example in the case of prairie restoration, leaving hedges on the edges of the site to block out street traffic or nearby businesses and parking lots. In other cases, it can involve slowing implementation, such as letting the big tree die naturally, or the honeysuckle hedge being gradually replaced by other more natural species.

The Future and Implications for Other Areas

The progress being made in northeastern Illinois with respect to large scale, coordinated ecological restoration efforts is a valuable model for resource management in other urban and urbanizing areas as well as many non-urban areas. Thoughtful planning, public involvement and communication are essential in the success of restoration at the small and large scale. As the scale of work increases, the effort becomes more complex but the basic tenets for success hold true.

Lessons learned from northeastern Illinois demonstrate that out of challenges come opportunities for higher levels of public involvement and understanding. A true dialogue between managers and the public guarantees that both parties will benefit. Effective dialogue requires true and open listening to alternative viewpoints, and must occur early in the process. Scientific information is a useful tool to help guide decision making; however, it should be used in context with information on the values expressed by the public. Balancing scientific information on ecosystems and their management with public values is a difficult challenge for planners and managers. In addressing that challenge, it may be useful to initially look to science for facts and to the public for values.

People are interested in natural resources and their management, but they are also busy. They want information that is relevant, easy to acquire and comprehensible. They are willing to learn about the natural environment and its management. They do not want to be listened to just for the sake of listening, and they can see through superficial gestures. They are not necessarily against having experts make decisions, although they want to be told the truth and to have their concerns heard and responded to, even if it is to say that what a person suggests is not feasible. This was very clear in discussions of Asian longhorned beetle control strategies with residents of neighborhoods where the pest had become established.

Informed, bi-directional public involvement can also lead to greater support for ecological restoration programs in the form of monetary support as well as in-kind and volunteer labor support. This support also can form the basis for strengthened constituencies for the acquisition of more natural areas. The greater and better job public and private agencies do in bringing the people into the planning and decision-making process and engaging them in what is happening, the more likely it will be that ecological goals can be met.

Northeastern Illinois and Chicago are not unique in the types of people who live there or the types of challenges facing people trying to balance the natural and the built worlds for the benefits that both can provide. What has worked here also may work elsewhere.

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Fragmented Midwestern Forests and Songbird Populations: Where Do We Go From Here?

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The central hardwood forests of the midwestern United States range from extensively forested to highly fragmented. Forest fragmentation is a major conservation issue in the region and affects land-use planning and management (Thompson et al. 1996, Faaborg et al. 1998). Much recent research has addressed the effects of forest fragmentation on songbirds (see reviews by Faaborg et al. 1995, Robinson and Wilcove 1994), and the Midwest has some of the best-documented examples of the effects of fragmentation (Robinson et al 1995). High variability in the reproductive success of songbirds has hampered our understanding of factors affecting populations. The needs for better information on species status, mechanisms for fragmentation effects and the balance of source and sink habitat make it difficult to recommend specific mitigation measures, or to determine if mitigation measures are even necessary. The diverse and sometimes competing habitat needs of wildlife such as forest birds further complicate conservation planning.

I compiled some statistics on the levels of fragmentation in the central hardwood region and used data on changes in land use to try and provide some temporal perspective on fragmentation. I reviewed the current state of our knowledge on the effects of fragmentation on forest birds in the region and suggest conservation and research approaches for mitigating negative effects of fragmentation.

How Fragmented Are Central Hardwood Forests?

Habitat fragmentation is a disruption of habitat continuity (Lord and Norton 1990). It can range from the effects of small patches created by some disturbance process in an otherwise intact habitat matrix to habitat insularization where only small habitat islands exist in an inhospitable matrix. Forest fragmentation generally reduces average forest patch size and the amount of forest interior or core area. Core area is defined as the area of habitat at some defined distance from habitat edge (Temple and Wilcox 1986).

The central hardwood region has been generally defined as oak-dominated forest lying south of the beech/maple forest, east of the Great Plains, and north and west of the southern pine forests (Hicks 1998). It generally coincides with (1950) oak/chestnut, mixed mesophytic, western mesophytic, and oak/hickory forest formations. For my analyses, I used the ecoregions map of North America (Bailey 1998), which identifies a national hierarchy consisting of ecological domains, divisions and provinces defined primarily by macroclimate. The Hot Continental Division largely corresponds to earlier definitions of central hardwood forests (Figure 1), but follows the distribution of oaks farther north than some earlier definitions. The advantage of the national ecological hierarchy is that it ties into national, regional and local planning efforts, is a hierarchical system, and has a strong ecological basis.

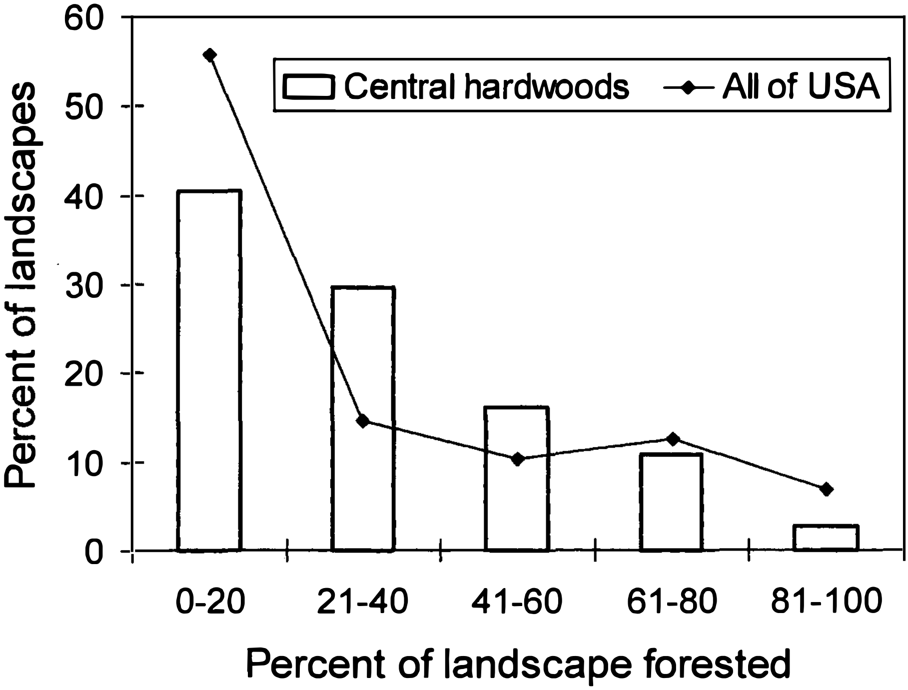
There is no specific measure of fragmentation, but levels of fragmentation can be inferred from a variety of landscape and patch-level statistics. One way to describe levels of forest fragmentation is to examine the amount of forest cover in a landscape. The percent forest cover is a useful statistic because it is easy to measure, can be correlated with other landscape measures such as patch size and the amount of edge, and has been correlated with wildlife abundance and reproductive success (Donovan et al. 1995, Robinson et al. 1995, Thompson et al. 2000). I determined the amount of forest cover in central hardwood landscapes by overlaying 38 10,000-square-mile hexagons over a map of forest cover in the hot continental division. The forest cover map was constructed from a forest type map developed from advanced very high resolution radiometer (AVHRR) data (USDA Forest Service 1992).

A map of forest cover shows how variable levels of forest fragmentation are in the region (Figure 1). Landscapes in the region ranged from 1 to 82 percent forest cover, with a mean of 30 percent. I compared this to the distribution of percent forest cover in the 321 hexagons that covered the entire continental United States to provide some perspective on level of forest fragmentation in central hardwood landscapes (Figure 2). The distribution of forest percentage in these landscapes is similarly shaped. Central hardwoods, however, have fewer landscapes that are heavily forested (>80 percent), fewer that are sparsely forested (<20 percent), and more in intermediate levels of forest cover than United States as a whole. The extremes of this distribution may be particularly important. For example, forest-bird reproductive success is often highest in the landscapes with very high levels of percent forest (>80 percent [Robinson et al. 1995]), and open-lands wildlife may do best in the landscapes with the fewest trees. An abundance of landscapes in the intermediate range of percent forest cover may represent the most fragmented state possible, when both open-land and forest species are considered.

I also assessed levels of forest fragmentation by determining the distribution of forest-patch sizes. Levels of fragmentation are generally assumed to

Figure 1. Forest cover in the Eastern United States and boundaries of the hot-continental ecological division.

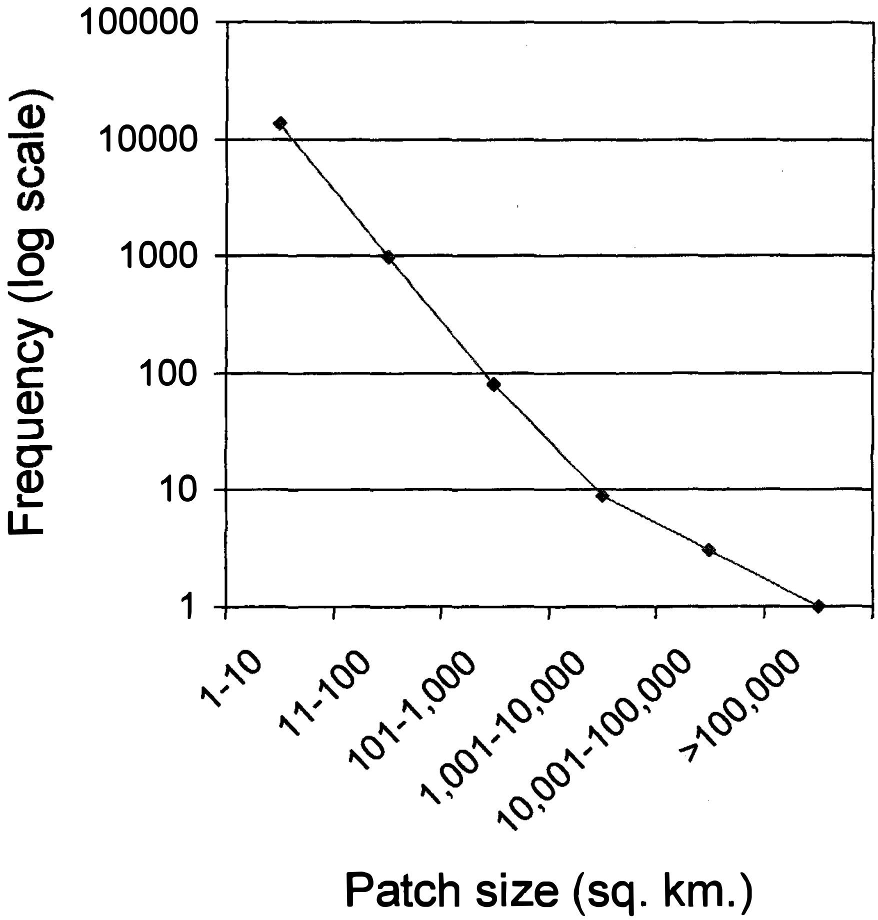
Figure 2. Percent of landscapes defined by 10,000 acre hexagons in the hot continental division (n=38) and the entire United States (n=321) that fall in four categories of percent forest cover.



increase with decreasing mean patch size because smaller patches have more edge in proportion to area and less core area. Median and mean patch size in central hardwood forests were 1 and 21 square kilometers, respectively. The distribution of patch sized follows a reverse J-shaped curve or a straight line when plotted on a logarithmic scale (Figure 3). Many small patches dominate the distribution, and there are only a few very large patches. This distribution is typical for many types of habitat patches (Hunter 1990).

These simple statistics provide an indication that these forests are fragmented, however, some large patches and heavily forested landscapes exist. However, a temporal perspective also is needed to understand the conservation implications of these data. For example, on average, are these forests more or less fragmented than they were 30 or 300 year ago? Unfortunately, only general patterns in land use can be determined over these time scales from various forms of inventory data or explorers' notes. There are a few classic examples at a local level in the Midwest, such as the fragmentation of forest habitat in Cadiz Township, Wisconsin, from 1831 to 1950 (Curtis 1956). There is the potential to assess levels of fragmentation over time spans of 20 to 50 years

Figure 3. Distribution of forest-patch sizes in the hot continental ecological division.



from satellite imagery and aerial photography, but no one has attempted this at the scale of central hardwood forest or the Midwest.

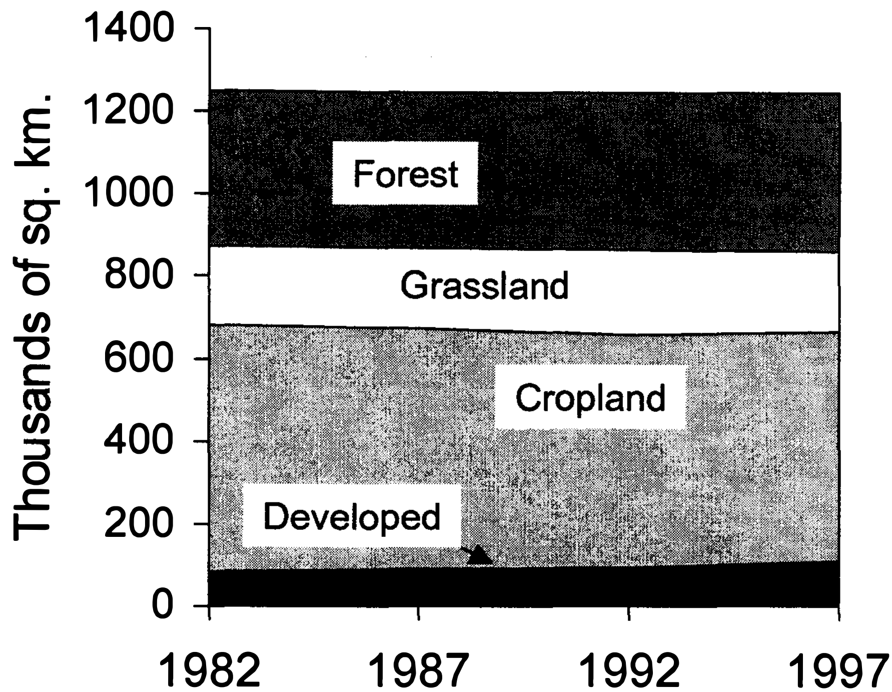
As an alternative I looked at some general patterns in changes in the amounts of various land uses. There has been an increase in the total area of timberland in the Midwest since the late 1970s and early 1980s. This is largely due to conversion of cropland and pasture to timberland (Schmidt 2000). The average tree size-class is becoming larger, which is indicative of aging stands and decreasing levels of disturbance from natural causes or harvesting (Schmidt 2000).

To get another indication of changes in land use in the region I compiled data on states with a significant component of central hardwoods (Missouri, Illinois, Indiana, Ohio, Kentucky, Tennessee, Iowa, Minnesota, Wisconsin, Michigan) from the National Resources Inventory 1997 report (U.S. Department of

Agriculture 1999). I plotted the amount of land in developed, cropland, grassland (range + pasture) and forest during 1982, 1987, 1992, and 1997. In addition to small increases in the amount of forest (as mentioned above), the amount of developed land has increased and amount of cropland has decreased (Figure 4).

At a regional level these data indicate a fairly stable picture of land use in the region. The lack of spatially referenced data, however, is problematic for assessing fragmentation. For example, while there has been a net increase in forestland, some forestland has been developed and cleared for agriculture. At the national level from 1982 to 1997 there has been a net conversion of almost 8 million acres of forestland to cropland, range, or pasture, and approximately 11.7 million acres of forestland converted to developed land (U.S. Department of Agriculture 1999). The spatial distribution of changes, as well as the conversion of agricultural land to forest, has potentially great impact on levels of fragmentation. So, although net amounts of major land uses have not changed

Figure 4. Trends in major categories of land use for 9 midwestern states (Missouri, Illinois, Indiana, Ohio, Kentucky, Tennessee, Idaho, Minnesota, Wisconsin, and Michigan), 1982-1997.



greatly in the region in the last 15 years, we do not have good measures of how fragmentation has changed, either recently or historically.

Fragmentation Effects on Songbirds

The effect of fragmentation on songbirds has been studied far more than for any other wildlife. I focus my discussion on this group because we have the best information on birds, even though some other taxa are more likely to suffer from fragmentation. Taxa such as amphibians (because of poor dispersal) and large mammals (because of sensitivity to humans) are likely to be negatively affected by fragmentation.

Effects on Species Distribution

The first evidence of negative consequences of fragmentation for songbirds came from area-sensitivity studies. Forest-dwelling songbirds are not randomly distributed with regard to fragment size (Ambuel and Temple 1983, Blake and Karr 1984, Hayden et al. 1985, Robbins et al. 1989). More species, especially forest-breeding, neotropical migrants, tend to occur in larger patches. Investigations of the distribution of individual species have resulted in the development of minimum area requirements. Minimum patch size for the presence of species ranges from a few hectares to thousands of hectares (Galli et al. 1976, Hayden et al. 1985, Robbins et al. 1989).

While minimum area relationships have been documented, the mechanisms for them are not clear. Hypotheses include the MacArthur-Wilson equilibrium theory (MacArthur and Wilson 1963, 1967), low reproductive success on minimally sized-fragments (Temple and Cary 1988, Robinson 1992), and behavioral avoidance of edge or small patches. From a conservation perspective area-sensitivity can be viewed negatively, because potential habitat in small patches is unoccupied; or positively, because species may be avoiding habitats where reproductive success is low. However, soon after the discovery of species area relationships, scientist realized the species and population dynamics in habitat patches could not be studied or modeled in isolation because patches were part of more complex landscapes. Bird abundances (Howell et al. 2000) and reproductive success (see below) were related to broader landscape patterns that patch size.

Landscape Effects on Reproductive Success

The general hypothesis for the effects of fragmentation on breeding songbirds is that nest predation and cowbird parasitism increase with forest fragmentation at the landscape scale because increases in the availability and interspersion of habitats rich in food, prey and hosts for predators and cowbirds results in higher abundance of cowbirds and predators and increased accessibility to forest-bird breeding habitat (Thompson et al. in review). The strongest and first empirical evidence supporting this hypothesis came from the Midwest (Donovan et al. 1995, Robinson et al. 1995, and Thompson et al. 2000). These studies measured many landscape variables but used the percentage of forest cover within a 10-kilometer radius as a simple measure of forest fragmentation and examined its correlation with daily nest predation of nine breeding songbirds. Correlations for all nine species were in the predicted direction, three correlations were significant ($P < 0.05$) and two additional species had P-values between 0.05 and 0.20. A combined probabilities test on all nine species indicated the overall effect of percentage forest cover was significant ($P < 0.02$). For all these species the highest nest predation rates occurred in landscapes with less than 40 percent forest cover. Given the high variability in nest predation rates over both time and space, we believe these results are indicative of an important relationship, even though some of the correlations were not statistically significant. In an important corroborative study, Donovan et al. (1997) tested hypotheses concerning edge and landscape effects on nest predation and parasitism. They randomly selected 18 landscapes from three states with high, moderate or low levels of fragmentation and determined predation rates of artificial nests in interior and edge habitat. Predation rates increased with forest fragmentation, and fragmentation (landscape) effects overwhelmed local edge effects (Figure 2).

Few studies have directly studied effects of fragmentation or edge on potential nest predators. Dijak and Thompson (2000) determined raccoons (*Procyon lotor*) and opossums (*Didelphis virginiana*) reach their highest densities in highly fragmented landscapes in Missouri, potentially because their distributions are associated with developed and agricultural habitats that are interspersed with forest habitat. In the Midwest, blue jays (*Cyanocitta cristatus*) are also more abundant in fragmented or edge-dominated landscapes (Howell et al. 2000, T.M. Donovan unpublished data).

The abundance of brown-headed cowbirds and level of brood parasitism also are closely related to forest fragmentation, perhaps even more so than predation. In the Midwest, cowbird abundance and levels of parasitism are closely correlated with landscape statistics, reflecting the amount of forest fragmentation and the amount of potential feeding habitat (agricultural land uses) in the landscape. Landscapes have been defined by 5- to 10-kilometer radii in these studies (Donovan et al. in press, Thompson et al. in press, Robinson et al. 1995), which relates well to the distances (<5 kilometer) most cowbirds commute between breeding and feeding areas (Thompson 1994, Thompson and Dijak in press). Landscape or fragmentation considerations seem logical for cowbirds because cowbirds utilize different habitats for feeding and breeding activities in the midwestern U.S. (Thompson 1994). In Missouri, female cowbirds tend to parasitize nests in host-rich forests in the early morning and move to open grassy or agricultural areas to feed as the day progresses (Thompson 1994, Thompson and Dijak in press, Morris and Thompson 1998).

Source-sink Population Structure

Source-sink theory (Pulliam 1988) is a useful population model for the population dynamics of organisms affected by habitat fragmentation. Pulliam (1988) used models based on births, immigration, deaths, and emigration (BIDE models) to describe geographic subpopulations that are connected by dispersal. Sub-populations are considered a sink population if local births do not balance local mortality, while they are consider a source if local births exceed local mortality. The overall population will increase or decrease depending on the balance among sources and sinks. Habitat fragmentation may limit reproductive success of songbirds in some fragmented landscapes in the Midwest to the point where they are sink populations and will either decline to extinction or will persist as part of a larger, source-sink system. Although no studies have directly tested source-sink population structure in songbird populations, there is evidence that reproductive success in fragmented midwestern forests is too low to compensate for adult mortality and that dispersal among habitat patches occurs (Donovan et al. 1995, Brawn and Robinson 1996, Trine 1998).

Conservation Implications

There is sufficient evidence to conclude that forest fragmentation in midwestern forests can reduce reproductive success of local populations of songbirds to the point where they may not be self-sustaining. It is not clear if these effects are currently limiting populations, but modeling suggests effects of the magnitude observed in the Midwest could cause declines in populations. This raises several important conservation issues which follow.

Is Fragmentation the Cause of Population Declines in Songbirds?

The research conducted to date in the Midwest and elsewhere suggests this is a plausible hypothesis, but we cannot yet conclude what the effect of fragmentation is on a species= population. To answer this question we need further confirmation of source-sink structure in populations and population viability assessments that account for the balance of source and sink habitat in a species, range.

Habitat Diversity Versus Fragmentation

At some scale, habitat diversity is required to meet the habitat needs of wildlife. Concerns about the effects of habitat fragmentation, however, should occur when habitat diversity is uniformly provided at small spatial scales and the viability of fragmentation-sensitive species is threatened. This generally occurs because species require large habitat patches or they suffer from predation, parasitism or competition from species in or invading from adjacent habitats.

Types of Fragmentation

Fragmentation occurs at many different scales and among habitats that vary in their degree of contrast. Evidence for effects of forest fragmentation on birds is primarily at the landscape scale and for agricultural or developed land use. These land-use practices provide food-rich habitats for predators and cowbirds in close proximity to forest-breeding songbirds. Other practices such as timber harvest may fragment forest habitats or structure, but do not likely have the same consequences for forest songbirds. These practices affect the availability of different aged forest habitats but may not elevate predation or parasitism levels in adjacent mature forest.

Most research on effects of forest fragmentation initially addressed forest interior songbirds that bred in late successional forest. More recently research has shown that shrubland or early-successional songbirds also may suffer low reproductive success and may be affected by the overall level of forest fragmentation. Even-though they are frequently referred to as edge species, shrub-nesting birds, such as prairie warblers, yellow-breasted chats, indigo buntings, blue-winged warblers, and field sparrows, may have higher reproductive success in non-edge situations, in larger habitat patches and in heavily forested landscapes (F. Thompson unpublished data).

Implications of Source-sink Population Structure

Source-sink population theory both facilitates and complicates wildlife conservation. For example, not all populations or habitats need to be sources. Source sink theory predicts populations will persist and even grow as long as population sources balance sinks. In the Midwest where eastern deciduous forest abuts prairies and grassland, there always has been some level of fragmentation and probably population sinks. The concern is that for some species that are declining regionwide, the balance has shifted between sources and sinks.

The prediction that subpopulations across the region are linked by dispersal also complicates conservation planning. The implications of this dispersal link are that management activities affecting one subpopulation can have consequence for others. The most extreme case of this would be that, if important source areas are degraded (such as by fragmentation), the persistence of sink populations and eventually the entire population, would be threatened.

Research Priorities

We need an assessment of trends in forest fragmentation to provide some historic context for current conditions. The central hardwoods border forest steppe and prairie ecoregions to the north and west, so there likely always has been some level of forest fragmentation where these regions meet. Fire has been an important disturbance factor in central hardwoods and maintained mosaics of forest, savanna, glades, barrens, and prairie (Dey and Guyette 2000). We do not know if current levels of fragmentation should be considered pathological from the perspective of wildlife or if they represent conditions that have existed for hundreds of years. Net changes in the area of different land uses have been relatively small at the regional level. We need better information on the spatial pattern of these changes to determine if they are increasing or decreasing fragmentation. Increasing area of developed habitats is probably the greatest threat for increasing fragmentation, yet we probably have the poorest knowledge of its effects on wildlife.

The importance of spatial and temporal variability to the persistence of populations is another important information need. Midwestern studies have shown spatial variability in reproductive success that is suggestive of source-sink population structure. As previously mentioned, we do not know the overall balance of source habitats and sink habitats and if this is driving population trends. Recent studies also have shown strong within season and annual variability in reproductive success; this variability also likely affects population viability. Another key information need related to source sink population structure is to identify links between subpopulations. Identifying key population source area and the sinks the support is critical to effective regional and local conservation efforts.

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Session Three.
Managing Wildlife-related Conflicts

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Issue Management and Communicating Effectively: "Why Biologists Need Help"

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More than 10 years ago, the International Association of Fish and Wildlife Agencies created the Proactive Strategies for Fish and Wildlife Management Project. The purpose of Proactive Strategies (PAS) was to build needed public awareness of scientific resource management. Until that time, no one in the conservation community or the state agencies really took to heart the threat that existed to wildlife management. It wasn't until other constituencies, such as the animal rights proponents, began to question the notion of hunting and trapping as proven methods of wildlife management that people in the conservation community began to realize they were quickly losing ground with the general public.

The landscape has certainly changed over the years. Currently, we face controversial issues such as ballot initiatives, funding issues, clashes over endangered species reintroductions, management of native versus non-native species, legislative challenges at the state and national levels, not to mention the continual controversy over the use of traditional methods of wildlife management such as hunting and trapping.

Some of these issues are not new, but what has changed is that they become magnified as we are bombarded by powerful tools of communication such as the Internet, newspapers, radio, magazines and the extraordinary expansion of cable and satellite television. Add to this the changing demographics in the United States, which have altered public perceptions about fish and wildlife management and participation in outdoors recreation, and you have a volatile mix of issues just waiting to become crises.

Today, every conservation organization and state agency is committed to building public awareness of scientific resource management which was the major goal of Proactive Strategies. Some have done an outstanding job of managing issues that have resulted in legislative victories for wildlife management. Unfortunately, while some progress has been made over the years, collectively our progress in effectively managing issues and communicating our messages has been insufficient.

To effectively manage issues and communicate with the public, the conservation community must embrace the discipline and implementation of issues management. If we don't, we will fail to win public support for wildlife management programs and the wildlife that we so earnestly cherish will suffer for it. In some cases this has already happened. Public sentiment has actually prevented trapping in situations where endangered species need to be protected from furbearing predators. The California clapper rail and other threatened and endangered birds are currently at risk due to the anti-trapping initiative that was passed by well-meaning, yet misinformed voters in California.

Nuts and Bolts of Issue Management

The "father" of issue management, Howard Chase, developed the classic model for this discipline in 1977. It begins with this definition: An issue is a gap between your actions and stakeholders' expectations. Issue management is the process used to close that gap.

Using this basic definition, one can look at the process of issue management in one of three ways: (1) change actions to be more in line with the expectations of your customers; (2) change the expectations of customers; or (3) apply a combination of these strategies.

An important aspect to keep in mind when implementing this process is the involvement of your organization's staff. You need to involve your public relations staff, information and education staff, directors and policy people. It takes a team effort to bridge the gap between your actions and your customers' expectations. It cannot be done in a bureaucratic vacuum.

Issues management is an ongoing process, which requires you to identify the questions the organization may be least prepared to address. It is intended to forecast developments that can have an impact on the organization followed by the development of responses and action plans. With any issue management process, it is wise to act promptly. If you like to procrastinate or have the urge to stick your head in the sand, the ultimate outcome is a crisis management issue. This is the type of trauma that prompts state legislatures and Congress to overreact and pass legislation that is either unwarranted or ill conceived. Crisis management issues can create negative headlines that ruin your organization's credibility and erode your funding base.

Let's look at the original Chase model of the issue management process, which consists of five primary steps: issue identification; issue analysis; issue change strategy options; issues action programs; and evaluation of results. On the face of it, the process can seem rather basic. It is not. It requires time and research, and again, the involvement of your staff. Unfortunately, if you're a state agency director or head of a major organization, you may already be knee-deep in your own brushfires, and you may not realize the importance of making the time to get out ahead of the issues. Instead, the issues may be chasing you! However, once you commit yourself to this process, try to think of it in the same way you, as biologists, apply science when looking at wildlife and habitat issues. Issue management is a science too—one that also relies on research and facts.

Issue Identification

The first step of identifying your issue(s) relies on your ability to look at major trends. This includes political, social, technological and economic trends. Depending on the business you are in, you may want to view these trends globally, but always with an eye to your local market. Next, you compare the trends with your business plan. If your goal is to initiate conservation projects in developing countries, the political and economic stability of those nations is vital to your timing and success. Next, select your primary issues.

Issue Analysis—Great Expectations!

This particular step requires a look back at the history of the issue and your past experience with it combined with the current expectations of your public. You must also review how your organization is geared to handling the issue.

Perhaps you need to bring in experts to help you. Or, maybe you need to raise more money to help your organization bridge that gap between your actions and your customers' expectations.

The fundamental breakdown in issue management is the inability of organizations to properly identify the expectations of their customers. It is one thing to understand generalities such as who is pro-hunting versus anti-hunting, but it is another to dig deep into the customer's beliefs and values. This is especially true when it comes to issues specifically relating to the consumptive use of wildlife. This step must be done scientifically by experts in the field of human dimension research. You cannot always assume to know what will move your constituents to the point of acceptance or support of your actions.

One example that stands out comes from the fur industry. A program the industry was compelled to implement in the early 1990s was based on the idea that fur is a natural product with great environmental value. After all, the theory, according to furriers, was that harvesting overabundant furbearers was good for the environment. Indeed, they reasoned fur was good for the environment because it was biodegradable and did not require the use of petrochemicals, as most synthetic fibers do.

Consumer research later proved that this idea held no real meaning to the public. In the meantime, the public was wondering why the fur industry wasn't communicating simple facts that they needed to know such as the fact that endangered species are not used for their fur, that government regulations are stringent and farm-raised animals are humanely treated. Sadly, many years and lots of money were wasted in trying to assure consumers that fur was an environmental product. It would have been an even greater tragedy had the industry ignored the research and not followed new programs that addressed the expectations of the public. How can you convince the public that fur decomposing in a trash heap is good for the environment when over 60 percent of them think, or are not sure if, the fur trade uses endangered species?

The analysis that follows human dimensions research may actually confirm that your programs are working well, but undoubtedly it will point to adjustments that are needed. Don't be surprised if you learn your programs are missing their mark entirely. If they are, deal with it.

Wildlife and the American Mind by Mark Duda et al. (1998) offers an opportunity to learn more about your customers and what they are thinking about wildlife. The very first chapter stresses the importance of human dimensions research during the issue analysis phase: "Successful and effective fish and wildlife programs can be developed only when they are based on a thorough understanding of wildlife populations, habitats, and people. Although fish and wildlife management professionals approach wildlife and habitat management in a deliberate and scientific manner, many fail to apply the same principles to the people aspect of fish and wildlife programs. But because fish and wildlife management and conservation programs are as much social endeavors as biological endeavors, the profession's approach to working with constituents and publics must become as sophisticated as the biological and ecological approach to fish and wildlife management."

Issue Change Strategy Options

The third step in effective issue management is the Issue Change Strategy Option. This phase requires the decision making that will prioritize how you will most effectively deal with the issues based on the analysis. You will likely decide on a different strategy for each issue. You may decide to aggressively fight a ballot initiative or you may let another organization take the lead depending on your resources. You may decide that a particular issue needs to be broadened with more information being provided to customers, such as hunter safety during the fall months. Depending on your analysis, some issues will be more dynamic than others.

Issue Action Program

Once your strategy on each issue is determined, your programs will require a well thought out approach. This includes determining your goals, objectives and tasks. It also requires the commitment of your entire organization to work together, especially with your communications staff. According to George McGrath's 1999 manual: *Issue Management – Anticipation and Influence:* "Scanning the environment for problems and opportunities, evaluating their impact, establishing priorities, developing strategies and tactics, and measuring results are not only the components of issues management—they are part of effective communication planning.... Communicators who wish to succeed in today's competitive environment understand that the priorities of the organization and those of the communicator go hand in hand. Issues management links strategic planning and communication planning and improves the effectiveness of both disciplines."

Many fish and wildlife professionals are just beginning to recognize the importance of outreach and communication. Unfortunately, due to their lack of training in external communication skills, biologists and conservation professionals who have been expected to develop and implement communications programs in the past have not met with rousing successes. This is precisely why the International Association of Fish and Wildlife Agencies would like to rein-

Table 1. The top 10 stories that were followed most closely by the American public in 1999, according to the Pew Research Center for People and the Press.

Rank	Story	Close followers (in percentage)
1	Columbine High School shootings in Littleton, Colorado[a]	68
2	Death of JFK Jr. [a,b]	54
3	U.S. Soldiers captured near Kosovo	47
4	Hurricane Floyd's destruction	45
5	NATO air strikes against Serbia	43
6	Tornadoes in Oklahoma and Kansas	38
7	Cold winter weather	37
8	U.S./Iraqi military clashes	37
9	Senate impeachment trial	31
10	Crash of Egypt Air flight	30

[a] Ranked third in most closely watched news story of the 1990s

[b] 52 percent felt that news organizations devoted too much coverage to the death of JFK Jr., his wife and sister-in-law.

troduce the Proactive Strategies Program and perhaps why the TWS' National Conservation Training Center also is interested in developing a course on issues management.

If the conservation community doesn't improve its communications skills, we may very well lose the battle for the public's attention. Deafening propaganda put out by the anti-management movement has invaded the public psyche. Campaigns of misinformation have changed attitudes and distorted perceptions. Their streetwise and well-researched guerrilla communications tactics are known to push every emotional hot button.

Yet, it is important to know that only 3 percent of the American public actually live by the animal rights philosophy (shunning meat, leather, pet-ownership, etc.), and 15 percent say they strongly support animal rights ("Consumer Attitudes on Fur and Animal Rights," Responsive Management, 1996). In other words, it's easy to say you agree with a philosophical way of life but quite another to actually follow its mandates. These statistics point out that although Americans strongly support animal welfare (more than 80 percent), not animal rights, they don't always understand the difference between the two. Communicators within the conservation community need to understand this distinction especially when it comes to issues and crisis management.

Communicators and their organizations need to also appreciate the role the media play when planning an issue action program. We have all had our share of unfair media coverage. It seems that controversy is what the media wants, not substantive stories about the importance of wildlife management or the tremendous successes of the conservation organizations that have made the United States the shining example that it is (Table 1). But these are assumptions on our part based on our lack of success in getting our messages to the media.

Evaluation and Results

The final step of issue management is to evaluate your efforts and determine the results of your actions. Did they bring about change that helped resolve potential problems for the organization? Were the results something your organization found desirable? At this stage, the process, the issue management cycle, begins again. The important feature of issues management is that it never really stops – it should be a constant in your organization.

One of the more difficult aspects of issue management is the ability to properly evaluate your success. Failure is much easier to define. However, closing the gap between your actions and your customer's expectations does not happen over night. Therefore, it is important to evaluate your strategies, goals and objectives from the standpoint of making adjustments rather than having to start all over again.

An increase or decrease in product or license sales is an idication that your strategies and action plans are working. Ongoing human dimension research can help you define whether you are losing or gaining ground with the public. Your communications plans also can be evaluated to ensure you are reaching your audience and getting your messages across.

An example of evaluating a communications effort is the recent media effort by the International Association of Fish and Wildlife Agencies to publicize the document, "Bears in the Backyard, Dear in the Driveway." Point to Point Communications worked with Southwick & Associates to help the International's get the message out that there are serious economic consequences when hunting and trapping are taken away from wildlife management professionals. "Bears in the Backyard, Deer in the Driveway" was written utilizing research statistics from the Berryman Institute that made a factual and compelling case that hunting and trapping are essential wildlife management methods.

The media strategy was evaluated on how many consumers were reached and what it might cost to pay to advertise the research rather than issue press releases, identify and train spokespeople, and diligently work with reporters, outdoor news writers and other conservation partners. Obviously, a media blitz is much cheaper than an advertising effort, but the end result, in terms of media coverage, is often dependent on many factors. "Bears on the Backyard, Deer in the Driveway" reached more than 4 million consumers through the general print media. This doesn't include the hundreds of thousands, if not millions, of sportsmen and women who read about the report on The Wildlife Society's web site, Safari Club International's magazine, or through articles written by hundreds of outdoor writers who received the report. Had comparable advertising space been purchased in each of the newspapers that carried this important story, it would have cost more than $250,000.

Evaluating your efforts is extremely important. However, it cannot be emphasized enough that public attitudes do not change overnight and those programs need time to truly be effective.

Conclusion

The conservation community needs to focus its efforts on the issue management process, paying close attention to the science of human dimensions research and effective communications strategies. Knowing and understanding your customer is the key. Utilizing professional communicators to implement your strategies can make all the difference in ensuring a successful outcome.

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Co-management: An Evolving Process for the Future of Wildlife Management?

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Public involvement in wildlife management has evolved considerably over the past half-century. The early decades of the profession were characterized by nonsystematic direct public input. Wildlife managers became more inquisitive about both traditional and emerging stakeholders during the 1970s and 1980s, a period when studies of key stakeholder groups became increasingly common. The 1990s ushered in an emphasis in transactional approaches for wildlife management. These were characterized by several forms of interactive personal involvement of a growing diversity of stakeholders (Decker and Chase 1997). Stakeholder involvement in making and implementing wildlife management decisions is still on the rise. Stakeholder interests in optimizing benefits or minimizing detrimental impacts of wildlife motivate participation in the regular management functions of defining species population goals, setting hunting seasons and evaluating hunting regulations. Most state wildlife agencies currently engage stakeholders in some form of transactional involvement, either in an ad hoc basis as the need is identified or in more routine input processes.

Looking ahead, the profession can expect continued evolution in the interest of the public in wildlife issues and active involvement of stakeholders in wildlife management (Chase et al. 2000). These will be exciting times for wildlife management, presenting many opportunities to benefit society via the wildlife resource. But capitalizing on this potential will necessitate considerable change in the wildlife profession. It will require a fundamental redefinition of the roles and relationships between wildlife professionals and the people they serve. Our paper attempts to frame such a change.

Co-management—A Framework for Effective Management

Although stakeholder involvement in wildlife management undoubtedly will take many forms, we believe that the concept of "co-management" offers excellent possibilities for wildlife management in the future (Schusler 1999). N o single, widely accepted definition of co-management is apparent from the natural resource management literature on the subject. Most reported experience has been from fisheries, forestry and protected areas. Often early examples included shared management between a federal or state/provincial government and indigenous peoples (for a wildlife example from Canada see Osherenko 1988). Recently the concept of co-management has appeared more frequently in reference to wildlife management (e.g., Decker and Chase 1997, Kruse et al. 1998, Pearse and Wilson 1999).

Co-management, which refers to a range of activities rather than one specific process, has been described in a variety of context-dependent ways (Schusler 1999). The term has been used interchangeably with cooperative management, collaborative management, joint management, participatory management, and multi-stakeholder management (Berkes and Henley 1997). As a foundation for our discussion, a useful general definition adopted by the World Conservation Congress (International Union for the Conservancy of Nature 1997:43) is: "[Co-management is]. . . a partnership in which government agencies, local communities and resource users, non-governmental organizations and other stakeholders negotiate, as appropriate to each context, the authority and responsibility for the management of a specific area or set of resources."

This definition emphasizes that co-management is a partnership between multiple stakeholders in which the specific arrangements for sharing responsibility vary or are "negotiated." Co-management usually occurs in situations where an agency that is legally mandated sole responsibility for management shares or delegates some portion of that responsibility.

Co-management thus signifies a sharing of authority and responsibility. Sanctioned sharing processes might involve partners from local government, groups of hunters or landowners, the general citizenry of a local area, non-governmental organizations, private enterprise or a special committee or task force. Processes might be officially requested or emerge from grassroots interest.

Co-management represents an appropriate, and we believe evolving, framework for wildlife management for two reasons. First, stakeholders have a right to share in wildlife-related decisions that affect their everyday lives. Second, wildlife agencies increasingly will need additional assistance to manage some types of wildlife impacts effectively. Many state agencies already are turning to outside assistance for selected management services (e.g., by sanctioning private wildlife nuisance control officers or wildlife rehabilitators). As populations of several game species continue to grow and the number of hunters slowly declines, additional partnerships may be required for effective management of those species.

This paper describes the challenges of co-management for wildlife management. We argue that the future for wildlife management lies in very different approaches than those relied upon in the past, and that a fundamental philosophical shift will be needed in the wildlife profession about the locus and nature of responsibility for wildlife management.

Co-management—A Range of Approaches

Several authors (Berkes et al. 1991, Pinkerton 1989, 1994, Borrini-Feyerabend 1996, Sen and Nielsen 1996) have conceptualized a continuum of management approaches anchored on one end by solely central-government management and on the other by entirely community- or stakeholder-based management. Co-management describes the variety of power and responsibility sharing arrangements that fall between the two end points. It is important to remember that co-management occurs at a particular scale. Assessing how decisions at that scale fit into the context of larger scale considerations typically is the domain of the legally declared authority—a state agency, supra state agency, federal agency, or international coalition.

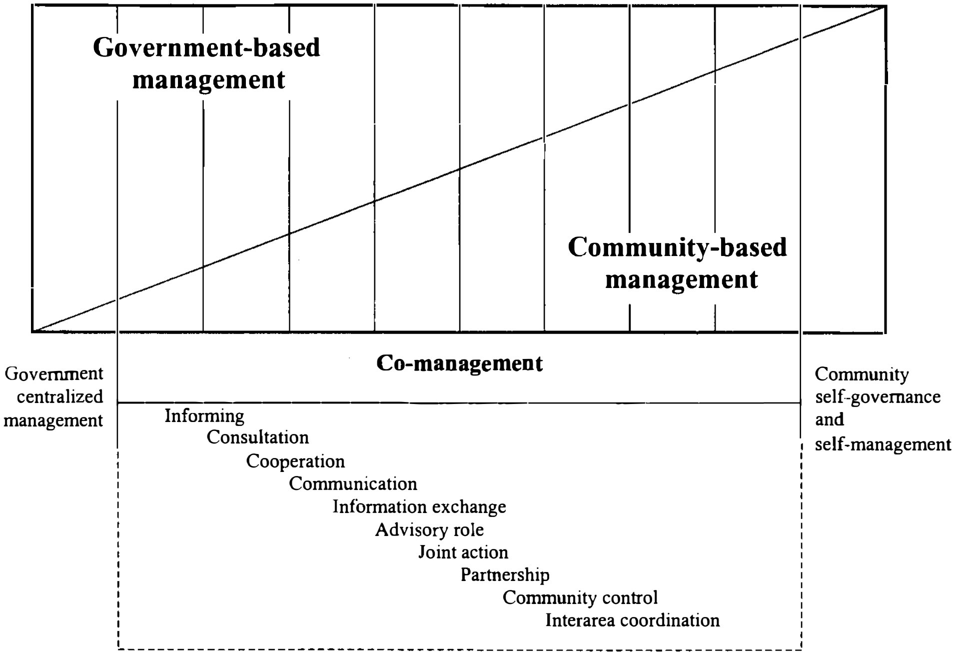
Pomeroy and Berkes (1997) describe a breadth of co-management possibilities that lie along a gradient of relative extent of government-based versus community-based management. Co-management covers various partnership arrangements, degrees of power sharing, and levels of integration of local and centralized management systems. Pomeroy and Berkes identified a hierarchy of co-management arrangements, ranging from the government agency simply consulting with stakeholders prior to an action to the stakeholders designing, implementing and enforcing regulations with advice and assistance from the government (Figure 1).

Co-management Benefits and Challenges

Benefits

In general, the benefits sought by one or all of the stakeholders in natural resources co-management are more appropriate management, more efficient management, and more equitable management (Pinkerton 1989). These broad

Figure 1. A continuum of co-managerial arrangements from government-based management to community-based management (adopted from Pomeroy and Berkes 1997: 466).



outcomes provide a useful framework for categorizing the many potential benefits of co-management that various authors have identified.

More appropriate management.

- Co-management improves the quality of data and data analysis and contributes to a better understanding of resource systems by bringing both scientific and local knowledge to the management process (Drolet et al. 1987, Pinkerton 1989, Borrini-Feyerabend 1996, McCay and Jentoft 1996).
- Co-management can better address the variation among local resource systems than general regulations imposed by central government (Jentoft and Kristoffersen 1989).
- Co-management can promote cultural sustainability of local populations (Berkes et al. 1991).
- Co-management has potential to promote community economic development where use of the resource brings commercial value to communities (Pinkerton 1989, Berkes et al. 1991).

More efficient management.

- Co-management may lead to more efficient management than that by central government by creating better coordination between interdependent stakeholders (Jentoft 1985).
- Co-management may reduce the transaction costs associated with conflict by providing a process for conflict resolution (Jentoft and Kristoffersen 1989; Pinkerton 1989). Increased understanding and knowledge among participants of the views and positions of others can also contribute to the prevention of problems and disputes (Borrini-Feyerabend 1996).
- Co-management also may reduce the costs of enforcing regulations because compliance is likely to be greater when those who experience the regulation are involved in making it (Jentoft 1985, Jentoft and Kristoffersen 1989, Borrini-Feyerabend 1996, Warner 1997).
- Co-management systems may be more flexible and adaptable in situations where contingency and change are paramount and learning is critical, as in adaptive resource management (Jentoft and Kristoffersen 1989, McCay and Jentoft 1996).

More equitable management.

- Co-management can lead to more equitable management because it brings stakeholders together around one table to address difficult decisions (Jentoft 1985, Pinkerton 1989).
- Co-management is a more democratic approach that can result in greater legitimacy of management because more stakeholders are involved in decision-making (McCay and Jentoft 1996).

Challenges

Co-management is not devoid of challenges. Its initial phases require substantial time, effort and resources as agencies and stakeholders revise their notions of management and develop the capacity to share responsibility. Challenges of instituting co-management begin with agreeing on the roles of partners in scoping the process. Additional challenges include:

- deciding who should participate and how;
- determining relevant geographic and temporal scales;
- deciding which resources co-management should cover;
- understanding how the political, economic and social contexts affect the arrangements in each specific situation (Schusler 1999); and
- periodic self-evaluation to maintain the successful elements and revise those that could be improved; co-management is a continuing process.

Important Considerations for Embarking on a Co-management Approach

The potential for co-management arrangements is enhanced when stakeholders (a) show a willingness to contribute time and money to management functions—from research to inform decisions through evaluation of actions taken—and (b) possess the organizational capacity to do so (Pinkerton 1989, Sen and Nielsen 1996, Prystupa 1998). Co-management arrangements are also more likely to develop when (a) opportunity exists for negotiation if the need arises or (b) partners can ease into their roles by initially focusing on a single management function (e.g., decisions but not implementation and evaluation), which later may be expanded to other functions as experience and trust develop (Pinkerton 1989). Trust among the stakeholders and agency staff is an essential element for success (Berkes 1997).

Cultural and institutional barriers are often cited as obstacles to developing co-management arrangements. Cultural barriers may be as basic as the difficulty of communication when participants speak different languages, or as general as the challenge of bridging different perceptions of problems and interpretations of information between resource managers and stakeholders (Drolet et al. 1987, Osherenko 1988, Smith 1995). Institutional barriers include agency resistance to sharing authority with local communities and agency organizational structures lacking flexibility to deal well with local participation (Pinkerton 1992, Little 1994, Little 1996). Conflicts with existing policy (Little 1996) and failure to legally recognize local rights (Pinkerton 1994, Berkes 1997) also have been cited as significant barriers.

The question of representation, or who participates, is a critical element of co-management. The choices involved in managing natural resources are not simply limited to who benefits and who loses. Basic to co-management are choices about who shall decide, who takes responsibility and how the decisions will be made (McCay and Acheson 1987). Co-management arrangements are more likely to be successful when clear criteria exist for membership or participation (Pinkerton 1989, 1994). Establishing criteria for participation can have significant consequences, as a common way to exert influence on management outcomes is through the definition of legitimate stakeholders. Much of the conflict in natural resource management concerns who has a legitimate voice in decisions about resource use (Paulson 1998).

Beyond determining who participates is the question of defining appropriate relationships among the stakeholder participants. The successful operation of co-management ultimately rests on the relationships among key participants (Pinkerton 1989). These relationships require cooperation, commitment to share both costs and benefits, an appropriate vehicle of conflict resolution, an equal negotiating relationship, improved organization among various stakeholders, and greater trust among all stakeholders involved (Pinkerton 1989). Agreement about the mandate from society as expressed through law is a needed condition for a relationship, too. The appropriate roles of stakeholders will vary with the interests and capabilities of stakeholder groups and with the types of management functions for which co-management is employed (Sen and Nielsen 1996). Co-management arrangements are more likely to be successful when appropriate roles are spelled out in a formal, multi-year agreement (Pinkerton 1989, 1994).

An equally important consideration is determining the appropriate domain to be covered by co-management. This includes the importance of *scale* and *level* (Sen and Nielsen 1996). Scale refers to the resource system and the management tasks to be undertaken. Clear geographic and resource boundaries increase the likelihood of successful co-management. These boundaries should designate management units that are of a scale appropriate to both human resources for co-management and the ecology of an area. Trade-offs occur between management units that are small enough to be easily monitored by community members and large enough for more comprehensive management of the resource (Pinkerton 1989, 1994). In addition, temporal scale considerations come into play. The time period over which management must occur to achieve the desired result and maintain it have to be estimated as co-management arrangements are designed. In wildlife management especially, commitments to management are not single episodes, but long-term and even "in perpetuity" types of commitments.

Level refers to where decision making should and does take place, namely local, regional, national or supra-national (Sen and Nielsen 1996). McCay and Jentoft (1996) suggest that decisions affecting people's lives should be made by the lowest capable social organization. This approach emphasizes local autonomy, where centralized authorities have the burden of proof about the need for centralizing a task. They also have an obligation to help strengthen the capacity of local institutions to retain or acquire management responsibilities. Balance should be sought between a devolution of power that allows greater community authority and accountability, and centralization of control to guarantee integration between local initiatives and regional or national policies (Feldmann 1994).

Two more critical elements of the co-management process are communication and processes for preventing or resolving conflicts. McCay and Jentoft (1996) suggest that more effective communication and more consensual discourse among stakeholders lead to socially responsible decision-making.

Constructive communication and civil discourse are difficult to achieve under conditions where conflicting interests have not been reconciled. Conflict resolution processes enable participants to find common ground and solutions that meet multiple interests. In some situations conflict management should precede development of co-management arrangements (or conflict resolution could be viewed as the first step in co-management development). Furthermore, co-management arrangements should build in the contingency that conflict resolution may be needed in the future.

Additional considerations in the development of co-management structures and processes include appropriate mechanisms for cost-sharing (Pinkerton 1994); legal definition of local powers (Pinkerton 1994, Berkes 1997); local empowerment, including the capacity of local organizations (Little 1994, Warner 1997, Prystupa 1998); economic incentives (Little 1994, Berkes 1997); the political and institutional context; and evaluation of the process itself (Little 1994).

Is the Wildlife Profession Ready for Co-management?

The need for improved stakeholder involvement in wildlife management is widely recognized. It appears that this is viewed by the profession as risky and difficult, but vital for the future of wildlife management. The nature of stakeholder involvement in the current management environment is transforming rapidly, but clearly the trend is moving from mere consent or perhaps cooperation, toward *collaboration*—really working together *meaningfully* with other agencies and stakeholders. Such collaboration among agencies and stakeholders is the essence of co-management as we have described earlier. This is a model where stakeholders are involved in most aspects of the management process, unlike the more typical approach where stakeholders are asked for input in just one stage of the process (Chase et al. in press). This move toward greater stakeholder involvement across the breadth of decisions and actions in wildlife management is a big and uncertain step for some agencies, but a natural next step in the evolution of stakeholder involvement for others.

The co-management concept, which is becoming institutionalized in other natural resource disciplines, has been discussed in a variety of professional wildlife management conferences and in several journal articles only very recently (Pearse and Wilson 1999). The responses from wildlife managers have been mixed. Some managers already are engaged in co-management. Some have yet to be involved in co-management, but see the possibilities that this approach offers for meeting the increasing demands they face. But many others are skeptical, concerned that co-management is the wrong way to go. Still others understandably question its practicality if it is not approached in some purposeful planned and prioritized way that can be supported by the resources of their organization.

The wildlife management profession has placed great emphasis on the need and value of "partnerships." Perhaps the slowness of the profession to more widely embrace co-management is because typical partnership programs do not truly share authority. In many partnerships costs are shared, work is shared, or an endorsement is given, but only a superficial sharing of authority occurs. Importantly, co-management unambiguously moves wildlife agencies toward gaining greater opportunity to manage and away from concern about retaining management authority. Some agencies seem reluctant to share authority, yet situations faced by wildlife managers today cry out for subduing concerns about protecting authority to manage and focusing more on the opportunities that co-management offer for agencies to do more management. Notions of public involvement built on the premise of keeping agencies in an authoritative, controlling relationship with their stakeholders are persistent, but pursuing this kind of relationship and a "we know what's best for you" mentality will be unsustainable in the 21st century.

A New Premise of Wildlife Management for a New Century?

We need a new premise for wildlife management, one reflecting the changing management environment, the evolution of the wildlife profession and needed relationships between agencies and their stakeholders to meet the needs for contemporary wildlife management. Decker (1999) suggested the following as a guide for wildlife management as we enter the 21st century:"Good wildlife management is not an agency exercising authority over, steadfastly retaining control of, or even taking responsibility for wildlife resources, but rather *wisely managing the sharing of responsibility for wildlife conservation with stakeholders*." In following this guidance, one must be clear of the distinction between the process of wildlife management and the role of professional wildlife managers. Managers need to lead as well as be a resource for a process that balances the needs of stakeholders over time, geographic space and different levels of human organization. Also in the balance is their individual responsibility as stewards for a public resource and their shared responsibility to participate as stakeholders in collective stewardship decisions involving those they have embraced as partners in co-management. These are not easy distinctions to operationalize.

Progressing toward this new premise requires commitment to constructing a future for wildlife management where enlightened professionals and the public agencies for which they work will de-emphasize but not abrogate "authority." They will take responsibility and leadership for legitimizing and facilitating (i.e., managing) processes that delegate control among partners. Agencies also will recognize that they share responsibilities with stakeholders who collectively have granted (and can withdraw) agency authority for management or public stewardship of wildlife resources.

No single prescription works in all situations. Agencies are going to have to take risks and be creative in the approaches they develop for sharing responsibility in specific contexts. This is not the time or place for public involvement technicians who have one or a handful of tools (e.g., "stakeholder involvement techniques") they apply to every situation. This is the realm of the artistry, as well as the science, in the art and science of wildlife management. Managers must learn (i.e., get wiser) from critically evaluating their experiences in co-management such that they will improve their performance in leading and managing co-management efforts. Done well, this notion of sharing responsibility wisely might become a key philosophical element and needed operational innovation to sustain the benefits of wildlife conservation in North America.

It may be a big hurdle for wildlife professionals to accept the reality that wildlife "issues" and, in most cases, their resolution are not "owned" exclusively by them. But if not shared, the responsibility for their consequences well may be placed upon wildlife professionals and their agencies. Stakeholders and their communities are co-owners of wildlife problems and opportunities. For many wildlife agencies, this perspective means redefining their roles and responsibilities vis-à-vis others who share a stake in wildlife management. Role redefinition may include the need to develop expectations that others assume their share of the responsibility for wildlife management.

Are Stakeholders and Their Communities Ready for Co-management?

The answer to this question lies at the heart of some of the most basic challenges and exciting possibilities for the future of wildlife management in North America. We believe the answer is generally, a qualified yes and no. Yes, *some* stakeholders in *some* communities want to embrace co-management. Not all communities, however, are prepared to do so. Nevertheless, communities are seeking tailored responses to "their" particular wildlife management issues. Many agencies are running ragged trying to respond. Typically communities come to recognize the limits of a state wildlife agency to accommodate the degree of the special attention they seek. They also frequently come to recognize their own community's capacity limits to fill in the gaps that the agency cannot service. We believe these needs point to a major opportunity for wildlife management agencies over the next decade.

Community Capacity Building

Many communities lack the institutions and capacity to deal effectively with the kinds of wildlife issues that are motivating their interest in involvement. They seldom have access locally (within the referent community) to the range of expertise in wildlife biology, social and biological research, or citizen participation processes needed to address their wildlife issues. Facilitating the development of needed community capacity (i.e., building local institutions and developing social capital) may become an important goal for wildlife management agencies. The interest that communities are expressing in addressing wildlife issues is an opportunity for intervention of this type.

Imagine the possibilities. If the capacity of community X to deal with wildlife issue Y is developed more fully, then that community should be able to make the continuing commitment to take the lead in managing that situation over time. Furthermore it should be equipped to deal with other wildlife management issues that may arise, and to do so with increasing efficiency. One community might even teach another! To paraphrase an old adage—give a man a fish and he eats for a day, teach a man to fish and he eats forever. Agencies working under this philosophy may not find the investments so high or the statewide scene so daunting.

But how does a wildlife agency staffed with biologists facilitate development of community capacity for dealing with wildlife issues? We believe there are several creative ways to accomplish this. First, however, one has to accept that what is most needed probably goes well beyond wildlife biology expertise. Community development expertise—process and planning capacity—may be the most important initial need. Certainly wildlife expertise—in both biological and human dimensions—will be part of the mix, but not the most critical element, at least initially. A consultant who is a community resource development specialist with general wildlife or natural resources background would be of tremendous value. This person could serve several communities within a region—as a sort of "circuit rider." Alternatively, cost-share arrangements could be made with existing community resources (e.g., cooperative extension educators) who possess the expertise needed. Small groups of people with several kinds of expertise (e.g., community resource development, public process experts, communication strategists, human dimensions specialists and biologists) working together could become community support teams operating within a region of the state. Many other possibilities exist that could work depending upon the situation.

Current Uses of Co-management in Two States

The New Jersey Division of Fish, and Wildlife's Community-based Deer Management Program, developed to address increasing deer/human conflicts in suburban communities, provides one example where an agency has formulated guidelines for co-management. Under the program, the Division "will cooperate with municipal, county, state, and federal agencies and other responsible entities (cooperator) to develop and implement alternative options for use in suburban environments where traditional hunting programs are not an option or where hunting programs alone cannot achieve the desired level of deer reduction" (Lund 1997). The Union County Division of Parks and Recreation was the first to enlist in the program in November 1995, to manage deer within the 800-hectare Watchung Reservation. Since the program's adoption, 28 communities have requested information or assistance with deer-control problems (R.C. Lund personal communication: 2000).

A Memorandum of Understanding between the Division and the cooperator clearly defines the sharing of responsibilities. While the Division provides technical assistance in the development, implementation and evaluation of control programs, all costs associated with the application of alternative options are borne by the cooperating entity. The Division has developed guidelines for alternative control options, maximum deer densities and additional conditions (such as discouraging the supplemental feeding of deer) to which cooperators must agree. The Division primarily acts as a resource for technical information. A community must decide if its residents believe that a deer problem exists and whether to proceed with a deer control plan (Lund 1997). This arrangement would correspond closely to a partnership on the co-management continuum shown in Figure 1.

The New York State Department of Environmental Conservation (NYSDEC) is accumulating experience and knowledge about co-management. A closely evaluated, pioneering co-management experiment for suburban deer has been going on for several years in Irondequoit, New York (Curtis et al. 1993). Responding to grass-roots stakeholder requests, NYSDEC embraced another suburban deer co-management effort in the Village of Cayuga Heights (a community adjacent to Ithaca) (Chase et al. 1999) In Islip and the Eastern Lake Ontario Basin, the NYSDEC instigated co-management experiments for deer and island bird resources, respectively. Each instance has had a concomitant research element for planning or evaluation purposes. So far all are "working out" even though some control was relinquished due to hesitation characteristic of anyone taking "first steps." The work with local communities on suburban deer problems falls within the center range of Figure 1 (joint action/partnership). The work on island bird resources currently falls on the left side of Figure 1 (informing, consultation, cooperation) while community capacity to deal with the issue is being enhanced.

In Irondequoit, Islip and Cayuga Heights, NYSDEC has allowed stakeholders to define the objectives of deer management. The agency is ready to participate in co-management that acknowledges that partners have much to contribute to defining the relevant information needed for making decisions and, therefore, has a role in setting the supporting research agenda (Mattfeld et al. 1998). NYSDEC also is proceeding with attention to the diverse desires of various communities regarding participation in co-management, using diagnostic tools to determine what approach is best for a particular community (e.g., Chase et al. 1999). It is not assumed that every community wants the same treatment, or even wants the more participatory systems of co-management that require considerable community commitments. But simply showing stakeholders the agency is ready to "right-size" a co-management approach with their community has improved the agency's situation. Mapping which steps to take to move forward with a continuum of co-management possibilities to address some hierarchy or prioritized set of community wildlife issues and finding the funding needed to do the job right remain the most important challenges.

Conclusion

As more communities have taken greater interest in their wildlife issues, some have shown willingness to accept greater responsibility for wildlife management. These communities have gained greater "ownership" in wildlife management. Legally, authority for wildlife management has remained with agencies, but practically, where co-management has developed, communities are taking a greater role and having a stronger voice in resource management. Some agencies concerned about loss of authority or control have viewed co-management with skepticism. However, other agencies have developed policies and taken actions that have kept them in the leadership role for wildlife management by delegating responsibility to stakeholders. In exchange, these agencies frequently have developed a better informed, more supportive and constructively involved public. This sharing of responsibility has provided welcome relief for agency personnel weary of being caught in the middle of more controversies than they can adequately address.

Although co-management is not a panacea and requires substantial time, effort and resources, when designed and implemented carefully (and preferably proactively) in appropriate situations, this approach holds the promise of greater stakeholder investment and satisfaction with management—and ultimately a stronger commitment to wildlife conservation. In many situations, the most effective wildlife management may not occur by an agency exercising authority over, steadfastly retaining control of, or even taking sole responsibility for wildlife resources, but rather wisely managing the sharing of responsibility for wildlife conservation between stakeholders.

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Beyond Release: Incorporating Diverse Publics in Setting Research Priorities for the Mexican Wolf Recovery Program

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Biological and Social Setting

During the 1990s, there was a decided recognition of the importance of stakeholder opinions and insight to making resource management decisions (Decker et al. 1996), although the general process was formalized as innovation diffusion many years earlier (Rogers 1995). Importantly, direct or indirect effects of local and broader economic views have been discussed in detail regarding effects on resource conservation practices (Olsen 1991, Shogren et al. 1999). Significant human dynamics exist in assessing and integrating these interests into decision-making processes (Coughlan and Armour 1992, Lipman-Blumen and Leavitt 1999). All of these methods of accomplishing resource restoration objectives have been synthesized recently (Geist and Galatowitsch 1999).

In March of 1998, the endangered Mexican wolf (*Canis lupus baileyi*) (classified in 1976) moved from being an animal known to exist only under the controlled supervision of a captive-breeding program to a part, once again, of the ecosystem of the mountains of the desert southwest. To help the wolf survive in this environment, the U.S. Fish and Wildlife Service (USFWS) Mexican Wolf Recovery Program needed to understand much more about the wolf—how it influences and is influenced by its environment. Through research, the recovery program can begin to reach this understanding.

We describe an effort by the USFWS to establish priorities for research that will benefit Mexican wolf recovery in the Southwest. Committed to an open dialogue with all those who have an interest in the recovery program, the Mexican wolf recovery staff from the USFWS, interagency partners, and the Cooperative Research Unit designed a process to prioritize research needs that offered interested parties a chance to contribute and a direct voice in identifying priorities in terms of local and diverse interests.

Establishing Research Priorities through Public Input

During summer and fall 1998, the New Mexico Cooperative Fish and Wildlife Research Unit implemented a process to identify research priorities for the Mexican Wolf Recovery Program. This process, involving people with various professional and personal backgrounds, identified research priorities that reflect the needs and interests from a variety of perspectives. The process to identify research priorities included two steps: a canvassing procedure and an interactive workshop. The canvassing process was conducted prior to the workshop, and results of the canvassing were provided to workshop participants.

Canvassing

Step 1 of the two-step process to identify research priorities involved canvassing 10 groups interested in issues surrounding the Mexican wolf and southwestern ecosystems. These groups included:

- biological researchers familiar with the Mexican wolf or southwest ecological issues;
- federal, state, and tribal resource managers;
- local agri-business representatives;
- government policy and management specialists;
- social scientists;
- natural resource economists;
- private conservation groups;
- sport hunting groups and outfitters;
- local government representatives; and
- the Interagency Management Advisory Group. (U.S. Department of the Interior, U.S. Department of Agriculture, U.S. Department of the Army, Arizona Game and Fish Department, New Mexico Department of Game and Fish, tribal representatives)

We asked three to seven individuals from each group (61 total) to (1) list specific or general research needs for Mexican wolf recovery, (2) rate those research needs as high, medium or low priority, and (3) describe factors used to rank research needs. All responses were organized and summarized in a spreadsheet to prepare materials for use at the workshop.

The Workshop

The workshop was the core of the process, giving individuals from interested groups a voice in identifying and prioritizing research on the Mexican wolf. The forum followed a nominal group technique, one of a number of group decision-making processes compared in detail by Coughlan and Armour (1992). The forum was moderated by an independent facilitator, Lucy Moore, with assistance from Melody Munson-McGee, Julie Prior-Magee, and Bruce Thompson of the New Mexico Cooperative Fish and Wildlife Research Unit. The interagency staff directly involved in the wolf reintroduction program was invited to observe but not actively participate.

All 10 interest groups were represented at a November 18, 1998 workshop held in Springerville, Arizona, a community near the reintroduction sites. Twenty individuals attended the workshop as participants representing their respective interest groups. Workshop participants were split into three smaller groups. Also attending the workshop were individuals who acted as observers and technical advisers. These included staff from the Mexican Wolf Recovery Program and the Arizona Game and Fish Department who were available to answer questions from participants.

The subgroups attempted to prioritize the needs and identify factors that influenced their prioritization. The overall group discussed the prioritization terms high, medium and low and noted that timing is an important element to these priorities. A certain need might be urgent in the short term; another need might be very important, but dependent on other information and therefore appropriate for longer-term planning. The participants decided to ignore timing issues and identify high priority needs only, without regard to short or long term.

Given the large number of research needs, reaching agreement on these priorities proved difficult in the small group and in the plenary format. Each group approached prioritization differently. Some participants were reluctant to cluster or collapse items together for fear of losing the importance of some items—particularly those involving socio-economic impacts. Many were concerned that the research be conducted in the context of a rural society, with sensitivity to the needs of those living and working in the area. They also hoped that some research projects could lead to information that could benefit rural life and protect rural values.

Next steps. Participants felt that the day's discussion had been useful but that there was not enough time to complete the prioritizing exercise. The group and organizers agreed that consensus should not be forced or assumed and that the three small-group facilitators from the Research Unit should take the next step. They were asked to document the brainstorming lists of each group so that each participant could recognize his or her contribution to the effort.

Because there was a general feeling that there was significant agreement among the groups, the facilitators also were asked to work together to find that commonality and create a merged report reflecting the work of the three groups. We agreed that participants would be sent their small group report for their opinions and later the merged report. The group agreed that participants should make an effort to reach informed consent—"seek unity by stepping aside" in the words of one. But it was emphasized that every participant has the right to dissent, and that if anything in the merged report is unacceptable, that person may reject the report by specifying his or her objections.

All participants received a copy of their group's summary for their review and comments. All participants that reviewed their group's summary concurred with these summaries as written or had comments that were incorporated into a written report provided to the USFWS (Thompson et al. 1999).

Outcomes

Canvassing Contribution

From the initial mailing and follow-up contact by postcard and telephone, we received 21 responses that identified 105 prioritized needs in 11 research categories. All groups were represented in the responses except social scientists and local government. Due to similarity in many of the research needs identified through canvassing, we summarized the 105 original list into 56 items in 10 categories (Table 1). This summary was available during group discussions. Participants identified 28 motivating factors that were important in prioritizing research needs (Table 2).

Workshop Contribution

Workshop participants (in the subgroups) identified 74 research needs categorized in a plenary session as social, economic, biological, management or monitoring, law enforcement, program evaluation, and miscellaneous. Additionally, 16 research needs identified from canvassing were evaluated during the workshop.

Although each group prioritized the research needs differently, there were clearly common threads among the groups. Each group consolidated research needs that encompassed individual research needs identified during the first half

Table 1. Summary of research needs for Mexican wolf recovery derived from preliminary canvassing of 21 respondents representing 10 constituent groups during October 1998.

Category	Research need
Behavior	Assess wolf acclimation to the wild
	Aversive conditioning to humans and factors other than prey
	Preconditioning in pens to natural foods
	Relate wolf behavior to release success
	Wolf interaction with domestic pets
	Wolf/human interaction (density independent factors)
Biology	Basic life history of wolves
	Basic wolf diet and related movements
	Diseases and parasites of wild and captive wolves
	Prey distribution and abundance in habitat fragments
	Wolf effects on ungulate populations
	Wolf habitat requirements
	Wolf interaction with natural prey species
	Wolf interaction with other predator species
Demographic	Identify wolf mortality factors
	Metapopulation viability analysis
	Survival of released wolves
	Wolf reproductive rate in wild
Depredation	Efficacy of livestock protection and depredation control
	Identifying features of wolf depredation on livestock
	Wolf livestock depredation related to age and sex of animals
	Wolf/livestock interaction in time and space
Economic	Estimate costs of conflict resolution
	Estimate economic effects of wolf presence on local communities
	Estimate reintroduction program costs
	Evaluate monetary compensation for depredation on domestic animals
General	Confirm wolf status in Mexico
	Develop model for international cooperation
	Evaluate binational recovery effort
	Identify factors in deciding about release program termination
	Improve estimate of time to recovery
	Relation of ecological factors to presence of wolves
Genetic	Assess genetic health of captive wolves
	Estimate wolf population features from genetic material
	Genetic profile of coyotes in release areas
	Investigate wolf taxonomy

Table 1. Continued.

Category	Research need
Habitat	Evaluate habitat and den site selection
	Identify recolonization habitat in western Texas
Methods	Detailed survey of wolves in New Mexico
	Efficacy of supplemental feeding post-release
	Evaluate alternative captive breeding management strategies
	Evaluate and prioritize release sites
	Evaluate other release areas
	Improve ability to estimate ungulate populations in wolf areas
	Improve husbandry and production of captive wolves
	Improve livestock husbandry practices in presence of wolves
	Improve techniques for sperm and ova collection and insemination
	Reported sightings in U.S. and Mexico
	Selection and preparation of wolves for release
Sociology	Assess human attitudes, voting choice, and media attention
	Describe attitudes of hunter licensees
	Develop manual for how to reduce wolf conflicts
	Enhance education materials and public outreach
	Evaluate factors in human fears of wolves
	Inventory stakeholder values
	Public attitude trend and outreach related to assessing release success

of the workshop. Several of these consolidated research needs developed by the groups were similar and included some of the same individual research needs.

Summary of Research Needs

Workshop participants in the three groups jointly identified seven broad research categories with many individual needs in each category (Table 3). For each consolidated need, the individual research needs that are part of that consolidated category also are listed. The individual research needs listed in Table 3 were given high priority by at least two of the groups. Although some of the individual research needs did not constitute a project of high priority when considered individually, their combination with other research needs to form a general research need gave them a higher importance rating.

Although the groups had limited time to discuss the factors involved in their ranking of high priority needs, some of the factors identified by the groups are as follows.

- Efforts to reintroduce the Mexican wolf in Mexico are critical to the recovery effort.

- Rural populations need to be treated as a distinct group made up of subgroups, not as part of the entire population. They are not adequately characterized as simply a "rural" section of the entire population of a state.
- Three criteria to use in assigning a high importance research need include: (1) a need that addresses some issue or situation that would stop or impede the recovery program; (2) a general need for proper and sound scientific information; or (3) a need to identify how local economies can capture economic benefits.
- A social and economic impact assessment is important because recovery will not work without the acceptance and tolerance of the local communities.

Table 2. Motivating factors associated with research needs for Mexican wolf recovery reported by 21 respondents to canvassing during October 1998.

Factor	Motivation factors for assigning research priorities
Conflict resolution	Avoid livestock mortality
	Avoid wolf/human contact
	Important to develop options to avoid contact with wolves
	Promote public safety and social or economic well-being
	Sense of information deficiency
	Understand human motivations
	Understanding human conflict and response
Economic	Benefit/cost assessment of recovery efforts
	Costs to recreational and hunting interests
	Detailed cost accounting and value to public
	Necessary for economic decisions
Methods improvement	Aid captive breeding
	Prepare release sites
	Validate estimates used in EIS
Opposition reduction	Gain hunting public acceptance
	Overcome challenges to recovery
Political	Aid to meeting public agency obligations
	Assess program accountability
	Need for larger recovery area
Program integration	Encouragement for cooperation
	Integration with other conservation initiatives
Release evaluation	Assess factors causing loss of wolves
	Assess long-range recovery program effects
	Benefits to reintroduction planning and implementation
	Checkpoint objectives
	Understand changing predator populations
	Understand ecological interrelationships with wolves
	Understand wolf effects on ungulates

Table 3. Research needs for recovery of the Mexican wolf as identified from canvassing during October 1998 and a workshop in November 1998.

Research area	Individual research need
Social and economic impact assessment with emphasis on rural sociology (includes education and outreach)	Identify rural norms and values toward biologists and government in the U.S. and Mexico
	Identify changes from recovery that are acceptable to the community
	Study effects of recovery on rural social structure
	Identify human health effects, children's interactions, risk perception, and rural emotional impacts, such as fears and stress, associated with different attitudes toward wolf recovery
	Identify common interests and reasons for support and opposition to target needs of different groups
	Describe and evaluate conflicting attitudes of interest groups
	Include Mexico in all surveys where appropriate
	Study public attitudes and outreach related to judging release success
	Assess public knowledge in distinguishing wolves from coyotes or dogs
	Identify sources of people's sentiments over wolves
	Develop ways to involve locals (as a research item)
	Quantify and measure economic effects on communities from recovery program and staff in the communities
	Identify ways to capture economic benefits of wolf recovery and wildlife to local economy and its growth
	Measure community resilience to changing land management and economics
	Estimate reintroduction program costs
	Identify important elements of the public outreach process
	Study ways to make technical results available and user friendly to the public through demonstrations/education
	Identify effective two-way education and information dissemination between agencies and rural and urban communities
Landscape ecology and use	Identify corridors and core areas across landscapes
	Determine how wolves use the landscape (distribution and land features), including dispersal patterns
	Determine effects of public land users on wolf families
	Determine how human-caused landscape changes affect wolf use of landscape
	Study causes and effects of ecological factors related to presence of wolves
	Evaluate habitat and den site selection
	Identify use of wolf territories compared with historical records

Table 3. Continued.

Research area	Individual research need
Predator–prey relationships (includes wolf/livestock interaction)	Identify impacts to prey base from, and interactions between wolves and all predators, including competing predators
	Estimate pre-reintroduction prey density and survival (long- and short-term)
	Identify impacts to sport hunting opportunities of ungulates from wolf recovery
	Determine causes of deer fawn mortality
	Develop ways to better identify predation by wolves versus other predators
	Determine food habits of released wolves
	Identify causes of livestock and calf mortality: timing of calving in relation to denning, husbandry practices, effect of release practices, breed and type of livestock, differentiation of wolf from other causes of livestock mortality
	Identify environmental versus genetic susceptibility of livestock to depredation
	Identify and evaluate livestock practices to avoid conflict with wolves
	Study preferred areas, preferred prey, and interaction between wolves, deer and livestock by radio collaring wolves, deer and livestock below the Mogollon Rim. Use a control and treatment area
Captive and wild production and release	Investigate and describe wolf behavior under intense human management
	Identify strategies for captive management and release strategies to promote wild behavior and avoidance of people
	Study aversive conditioning to humans and threats, e.g., roads
	Determine extent of viability and interference of wolf hybrids
	Evaluate release techniques
	Determine how captive wolf behavior relates to release success
	Conduct a metapopulation viability analysis
Genetics	Study genetic integrity and viability of captive stock
	Monitor hybridization of wolves and coyotes through genetic profiling
	Monitor captive population for inbreeding
	Estimate wolf population features from genetic material
	Develop a genetic profile of coyotes in the release area
	Maintain pedigree information

Table 3. Continued.

Research area	Individual research need
General biology and behavior	Identify causes of wolf mortality
	Assess integrity of wolf family groups
	Study general behavior and biology to address gaps
	Identify wolf social response to intervention with individual wolves
Mexican field studies	Conduct release site feasibility studies in Mexico (this is time sensitive and relates to Phase II of the project and the Mexican political environment)
	Conduct field research in Mexico to determine presence of wolves and to study behavior in the wild
Other issues	
Law enforcement	Identify law enforcement strategies to minimize illegal take of wolves
Program evaluation	Learn from the successes and failures from other programs—Yellowstone, Minnesota, Alaska, North Carolina—compare social and historical context
	Archive genetic and morphological material to support research
Conflict resolution	Address future conflicts and set up conflict resolution protocols
	Identify factors needed to keep collaborative decision making productive

One outcome would be better understanding among agencies of local communities.

- Social and economic aspects are the weak points of the program where the program could most easily be challenged.
- Comparison with other programs is important because the Mexican Wolf Recovery Program can learn from successes and failures of other programs. In this way, the Program would not have to reinvent the wheel and could improve its program effectiveness by applying the lessons learned from other programs.
- Some of the individual research needs, although important, cannot be addressed until there is a large, wild wolf population. Further, different research needs will need varied wolf population levels to enable investigation of specific demographic objectives. Because of these population limitations, high importance does not always reflect high priority.
- Some of these research needs are being addressed by ongoing programs. Workshop participants recognize those programs and encourage their continuance.

- Some of the individual research needs are important because they can be easily addressed by a related research program. Thus, some needs alone would not rise to the highest level of importance.

Evaluation of the Process

The workshop and canvassing process gave individuals from interested groups a voice in identifying and prioritizing research on the Mexican wolf. By involving people with various professional and personal backgrounds, the research priorities identified reflect the needs and concerns of groups with interest in both the wolf and the communities affected by reintroduction. This variety of perspectives will enable the Mexican Wolf Recovery Program to address the diverse needs of the Mexican wolf and the humans that share an environment.

Natural resource conservation professionals are realizing the critical importance of incorporating human dimensions into their resource programs and research supporting those programs (Decker et al. 1996, Loker et al. 1999). By including professionals with economic, social science, government policy, local government, and local agri-business backgrounds in research scoping, the Recovery Program has taken an important step in ensuring that the human dimension of the ecosystem will be considered.

The nominal group technique used during the workshop structured participation by a variety of interest groups. In planning for any workshop such as this, the organizers should be familiar with the options summarized by Coughlan and Armour (1992) and minimally consider the following:

- Bring together all facilitators prior to the workshop to ensure they all understand the goals of the process and share a commitment to facilitating the process to achieve these goals.
- Ensure enough time for open discussion of all ideas presented by participants. It is easy to plan too much during a day-long workshop. In the end, participants can leave feeling there was not enough time to adequately discuss and synthesize the subject.
- Ensure participants have a clear understanding of the purpose of the workshop and have been provided background material when necessary.

Participant Reactions

Feedback from workshop participants varied. Most participants attended an optional education session the day before the workshop. Many were enthusiastic about the workshop and the education session. All openly and actively participated in the process, although three could not stay the entire day.

There was general support for bringing together people who do not work for the government and are not biologists. At the end of the day, however, a small number of participants were wary of the process and hesitant to trust the USFWS to investigate the "high importance" research needs they identified.

Application of the Products

End products of the priority setting process have been used for several information dissemination and research purposes. All canvassing and workshop participants received a copy of the summary report (Thompson et al. 1999), thereby allowing them the opportunity to describe the process to colleagues and community members and show evidence of the outcome. Also, the USFWS has distributed the report to a variety of constituents, mostly private citizens and researchers at academic institutions. Further, the USFWS has used the information internally in the Mexican Wolf Recovery Program to narrow the focus on research needs and justify funding for two research projects. Those proposed actions include human attitude assessment and sociological survey in the wolf reintroduction area. This focus and decision making has value in communicating positive and consistent messages to constituents and the general public.

Some staff with the USFWS were surprised by the unified view of the interest groups involved that sociological research was a strong research priority. Previous perception was that sociological aspects had been thoroughly addressed during public scoping, environmental assessment and public involvement sessions. Recognizing these strongly held opinions has helped the USFWS to reassess priorities and to include some targeted sociological research in budget requests. Others interested in proposing or designing research to benefit Mexican wolf conservation may wish to critically evaluate the priorities identified and communicate with prospective research sponsors to assess consistency of view.

Substantial near-term value was achieved by the USFWS by gaining a greater awareness about involving the public and partners in funding allocation decisions. We observed that the USFWS developed goodwill at the workshop simply through more sincere requests for stakeholder opinions. Among some, however, this goodwill was tentative and will be strengthened or weakened depending on participants' perceptions of the resulting research program. Uncertainty remains about how much understanding of wolf research needs is permeating the general public. However, this approach to public involvement was innovative and represents an important step in the process of diffusing innovation in society as described by Rogers (1995). For information on how the Mexican Wolf Recovery Program proceeds in light of this added information and other challenges, consult the Mexican Wolf web page for future progress (http://ifw2es.fws.gov/wolf/).

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Balancing Public Opinion in Managing River Otters in Missouri

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State and federal wildlife agencies must consider social and cultural impacts of wildlife restoration as well as ecological impacts (Breidenbach and Goedeke 1999). Successes in recovering wildlife populations, once unquestioned by the public as socially beneficial, often now generate conflict, begging the all-too-real question posed in the contemporary movie, "Jurassic Park"—what animals should be restored to the landscape, where, in what numbers, and what do we do when there are unanticipated consequences of restoration.

The restoration and subsequent management of river otters *(Lutra canadensis)* in Missouri is a telling case study of both success and problems stemming from the reintroduction of a wildlife species. The Missouri Department of Conservation (MDC) has experienced diverse public perspectives and conflicting citizen expectations for otter management. Our insights may be helpful to other wildlife agencies that must now anticipate increased social conflict arising from wildlife restoration programs that are either unpopular among some segments of the public, or ironically, those that are inordinately successful.

Background

In 1982, MDC began restoring river otters to rivers and streams across the state, with the expectation that a regulated trapping season might eventually be needed 20 to 30 years in the future to manage the population, assuming the program was successful at all. During the 11-year effort, 845 wild-trapped otters, primarily from Louisiana, were released in 43 sites, using techniques subsequently employed in other Midwestern states (Erickson and Hamilton 1988, Bluett 1995, Johnson and Berkley 1999). Coincidentally, most of the otters captured in Louisiana for transfer to Missouri were taken in foot-hold traps.

Media exposure of MDC's otter restoration during the mid-1980s to the mid-1990s far exceeded that given to prior successful restorations, such as white-tailed deer in the 1950s and 1960s, and wild turkey in the 1960s and 1970s. Especially effective and popular were media events built around otter releases, focusing newspaper and TV coverage. Also, to spotlight its restoration of the wild otter population, MDC employed the services of biologist and cinematographer Glenn Chambers to present his traveling program featuring captive-born otters. Chambers' otters "Paddle-foot" and "Baby" thrilled and entertained audiences with their swimming abilities and appealing loping gate, as Chambers provided commentary on otters' life history. These programs evidenced the community and public approval associated with the restoration, belying controversy to come.

By the mid-1990s, statistical estimates, as well as anecdotal accounts and sightings by local residents, confirmed that otters had increased to unexpectedly high numbers, at least in some locales. Moreover, depredation complaints from pond owners and aqua-culture business-owners reporting fish losses to otters started to be heard in growing numbers and severity. Finally, otters in increasing numbers were taken to beaver and raccoon trapping, a situation not unanticipated by MDC as the population increased. Otters so taken by trappers had to be surrendered to MDC.

In response, a two-month statewide trapping season (November 20 to January 20) was implemented in 1996 allowing the taking of otters in any number. MDC requested export authority from the U.S. Fish and Wildlife Service (as is required for CITES listed species), and temporary permits were granted each year until final authority was obtained in 1999 after a prolonged effort. This authority was sought because, although not endangered, river otters resemble endangered otters in other countries. Trappers harvested approximately 1,000 otters in each of the trapping seasons from 1996 to 1999, even as trapper numbers fell from 4,899 to 2,744 during that time span, attributable to fluctuations in raccoon fur prices.

River otter populations are now widely restored across Missouri's rivers, streams, lakes, and even small farm ponds. Estimates of the statewide population of otters in 1999 vary from MDC's conservative projection of about 11,000 animals based on population modeling (Hamilton 1998) to an estimate by workers from the University of Missouri of about 18,000 (Gallagher 1999). Both estimates project continued growth of the otter population.

Public Response

The defining moment of what would become the "otter debate" was the establishment of the regulated trapping season for otters—an eventuality not anticipated by MDC to be necessary for perhaps a couple decades.

Otter Protectionists

Most immediate response was from local and national animal rights groups expressing outrage that an animal only recently restored would be subjected to the very threat that, by their descriptions, carried the otter population to the brink of oblivion in the first place. More to the point, however, "otter protectionists" simply objected to trapping. They claimed that trapping is cruel and unnecessary and that, if the public were aware of the realities of trapping, they would opt for alternative methods (unspecified) of wildlife management. However, annual surveys conducted for MDC by the Gallup organization revealed that about 70 percent of Missourians think "trapping is OK as long as it is regulated" (Missouri Department of Conservation 1997). Otter protectionists, although unwilling to accept the idea that the public at large acknowledges trapper rights, chose instead to attack the credibility of MDC's otter population estimates.

Two lawsuits questioning MDC's data were filed in attempts to, at first, stop the otter trapping season and, later, to block the granting of export authority to Missouri. The first lawsuit was filed against the MDC by a California-based animal rights group, Animal Legal Defense Fund (ALDF) and two Missouri citizens. In dismissing that challenge, the court ruled that MDC's otter trapping season was not "arbitrary and capricious" as the suit alleged, and that the MDC had followed all proper procedures in establishing the wildlife rules. The second lawsuit was again filed by ALDF, joined by the Washington, D.C.-based Humane Society of the United States, this time in U.S. District court against the U.S. Fish and Wildlife Service, in an attempt to use social pressure to override biological evidence. This one was dismissed by a federal judge who ruled that since the MDC was going to have a trapping season anyway, granting an export permit had no impact. Harsh rhetoric then threatened MDC with a ballot initiative to ban otter trapping. Apparently, river otters represent a compelling "poster child" for animal rights groups to gain membership and funding, and attempt to focus public debate on trapping.

The otter protectionists are a small but vocal group, based in St. Louis county, who receive virtually no media attention outside of the St. Louis metro region. However, the St. Louis metro region accounted for 37 percent of the Missouri voter turnout in April 1999 (St. Louis City, 5 percent; St. Louis county, 22.1 percent; and including the surrounding counties of Franklin, St. Charles, and Jefferson, 37.1 percent). Adding residents of Jackson (10.4 percent) and Clay (3 percent) counties (Kansas City metro) brings the urban voters to more than 50 percent of the state. Voters in St. Louis county single-handedly defeated a measure about the possession of concealed handguns in 1999; the measure was overwhelmingly approved elsewhere in the state, where it passed in 104 of the 114 Missouri counties. It must be emphasized, however, that many Missouri urbanites are only one generation removed from their rural roots and many have fishing and hunting interests (Missouri Department of Conservation 1992), and in fact, it was the urban voting block in Missouri that supported and carried the widely-hailed "one-eighth percent conservation sales tax" in 1976 (Brohn 1977). In any case, any ballot initiative on otter trapping probably would be decided by voters in the St. Louis area.

Anglers, Pond Owners and Aqua-culture Businesses

Some anglers, principally those who fish for smallmouth bass in the clear and relatively small headwater streams of Missouri's Ozarks, contend that the MDC was reckless in restoring otters to a landscape where game fish were vulnerable to otter predation. They point to degraded aquatic habitat in many Ozark streams that leave game fish especially vulnerable to otters' predatory efficiency. Anglers contend that problems such as gravel accumulation, siltation and nitrification from fertilizer and municipal sources have weakened the ecosystem, but smallmouth bass and other fish could still survive until MDC added otters to the list of problems fish had to deal with.

Pond owners tell stories of watching at first with fascination and pleasure as newly arrived otters frolicked in their ponds, only to discover that the otters were killing their fish-stocks in a feeding frenzy—often killing or paralyzing a fish with several bites, and only partially eating the catch before returning to kill yet another fish. Letters to MDC from some pond owners characterized otters as "varmints" and "a total disaster." The number of cases handled by MDC wildlife damage biologists has risen dramatically in the past three years—only 12 cases were handled by wildlife damage biologists in 1996, rising to 49 cases in 1998, with numerous second-hand accounts of unreported depredation. The MDC estimates there are approximately 300,000 privately owned fish ponds in Missouri, certainly among the highest in the nation.

Some aqua-culture businesses reported near-eradication by otters of certain commercial stocks, such as crayfish. Others reported controlling otters by trapping and shooting, but complained of the extra time and money spent on this only-partial solution.

At a bare minimum, anglers, pond owners and aquaculture businesses expected trapping seasons to reduce otter populations and to remove offending individuals, but expressed worry that trappers would be unable to control the damage that they thought was out-of-hand. Some advocated that MDC compensate pond owners experiencing otter depredation, that MDC hire otter trappers to eradicate otters from the Missouri Ozark streams, and that MDC even pay bounties as an added incentive for the public to trap otters.

In fact, a river otter food habits study in Missouri now in its second year suggests that otters prey on sport fish in higher numbers than other fish groups (family Centrarchidae, which includes smallmouth bass, largemouth bass, longear sunfish, and rock bass). Also, data indicate that 56 percent of the fish in this group that are eaten by otters in the Ozark region were more than four years old (age when most smallmouth bass would reach 12 inches in length) and approximately 20 percent were seven years of age or older (Missouri Department of Conservation unpublished data).

The "General Public"

The Conservation Federation of Missouri (an umbrella conservation organization for sporting groups, environmental organizations, garden clubs, and Missouri's state affiliate of the National Wildlife Federation) commissioned a series of focus groups by Fleishman-Hillard Research in St. Louis county to help learn about voter awareness, knowledge and attitudes of issues surrounding river otters in Missouri. Findings revealed that few St. Louis urbanites knew what river otters look like or knew any details about their existence in Missouri. However, they supported wildlife management and understood basic concepts of balance, and acquiesced that trapping was necessary to control otter populations and the damage that otters can cause to fish populations. Further, they thought that, if MDC had an otter problem, the agency should get on with fixing it.

Focus group participants associated "bag limits" with good management, and they trusted that MDC maintained these limits. No bag limits were perceived as irresponsible, perhaps leading to uncontrolled and undesired decline in otter populations. The idea of a regional bag limit made common sense to focus group participants. They agreed that a high bag limit might be necessary in some places and were comfortable with that idea as long as limits were in place.

MDC's Otter Advisory Committee

To clarify otter management issues further, MDC's Director Jerry Conley requested establishment of an Otter Advisory Committee in 1998. The citizen committee included anglers, an aqua-culture business owner, University of Missouri and MDC biologists, a county commissioner, a trapper and a member of an otter protection group. The committee addressed, discussed and disputed issues related to otter population estimates; the impact of river otter depredation on fish in private ponds and lakes, headwater Ozark streams and commercial aqua-culture businesses, as well as issues surrounding the trapping of otters.

Several management options were debated within the committee, from "kill no otters," to one that brought comic relief to occasionally tense discussions—that of calling for B-2 bomber strikes in areas of high otter concentrations in the Ozarks. Though not without dispute, the committee eventually recommended that MDC consider an adaptive strategy for managing otters based on the relative abundance of otters in Missouri. MDC staff responded by proposing five otter management zones with limits and season length extensions where appropriate, based on factors such as otter population indices, impact on public fisheries and damage to private impoundments. Basically, the proposal suggested a five-otter trapping limit in three zones adjacent to Missouri's three major metro areas—St. Louis, Kansas City and Springfield; a 20-otter limit in most of the balance of the state; and finally, a zone in which otters could be taken in any numbers and an extended 31-day season, focusing on Missouri's southcentral region (Ozarks and Mississippi lowlands) where the consequences of having otters have been particularly significant.

Even within MDC, however, this "five-zone and limits" proposal was controversial. Upon examining the proposal, MDC's seven-person Regulations Committee—six members and the chair (chair only votes to break a tie)—was evenly split between the five-zone recommendation and an alternative that would allow continued taking of otters in any numbers throughout the two-month furbearer season, while extending the season in locales especially affected by otter depredation. Opposing views of the five-zone approach asserted that increased complexity is not warranted because otter populations continue to grow even with the current "unlimited" trapping season, and that limits would be ineffective because few trappers ever reach a reasonably-set season limit and otters are often captured incidental to trapping for abundant species such as raccoons and beaver.

In the final stages of MDC's Regulations Committee's discussion, the Conservation Federation of Missouri and an angler representative of the Otter Advisory Committee both spoke for the five-zone approach, arguing: (1) it was based on the most current biological data on otter densities and was compatible with current harvest rates, (2) it was responsive to the polar views—"kill no otters" and "kill 'all' otters"—and was consistent with the Otter Advisory Committee recommendations, and (3) it had elements that could help alleviate otter damage in areas most affected.

Current Status

The Chairman of the Regulations Committee broke the tie vote in favor of the five-zone approach, explaining that it would focus otter control in those areas where otter populations are relatively high and where otter depredation appears most extreme, while providing for lower individual limits from areas where otter populations are relatively lower.

Concluding Remarks

Fish and wildlife agencies in North America manage living resources. The task is complex, involving biological information, land and water, fiscal constraints, agency mandates, legislation, political climate, and public sentiment. Perhaps most challenging in developing management strategies is the incorporation of public sentiment and human behavior, or what now are widely characterized as "human dimensions" in fish and wildlife management. These human dimensions include people's beliefs, values, knowledge, customs and laws; collectively, the moral demand system or ways of thinking and behaving best characterized as North American *culture* (Witter and Jahn 1998).

As if otters were not enough to provide management challenges for the MDC, the agency is now immersed in another controversy, that of considering the restoration of elk *(Cervus elaphus)* to Missouri's Ozark landscapes. Although the MDC did not consider diverse public opinion prior to the otter restoration program, MDC is attempting to gather quantitative and qualitative data on public opinion to help guide decisions on elk restoration, in addition to biological considerations about the appropriateness of such an action. During these debates, the otter restoration/disaster is having influence on the reputation of MDC with regards to sensitivity to the possible negative impacts on people and their culture/lifestyles. The Missouri General Assembly is considering legislation forcing the MDC to take financial responsibility for any damage that a restored elk population would cause, and the Missouri Farm Bureau and the Missouri Cattlemens's Association are actively campaigning against the restoration of elk in the state.

Resolving differences in views demands risk taking—not a overly common step in wildlife management. But a dying organization is one in which risky ideas are "endangered species" (Morgan 1989). Otter management in Missouri has challenged MDC to step outside its comfort zone in the pursuit of an adaptive strategy that has at least some small measure of appeal to widely divergent public views of how otters are best managed. The extent to which MDC—and other agencies facing similar issues—successfully incorporates public input—may well determine the extent to which future wildlife restoration proposals are received and endorsed by the public.

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Managing Overabundance in the Face of Social Conflict: The Case of the Lesser Snow Goose

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Wildlife professionals are becoming increasing involved with managing overabundant species, and these often are game species found in areas not open to hunting. White-tailed deer (*Odocoileus virginianus*) and Canada geese (*Branta canadensis*) are two of the more common examples of species whose populations have required different and perhaps unconventional management approaches. The recent population growth of light geese in central North America has added a new twist to the management of overabundant species.

Mid-continent lesser snow geese (*Chen caerulescens caerulescens*) and Ross' geese (*Chen rossii*) breed and nest in the eastern and central arctic and sub-arctic regions of Canada. They are referred to as "light" geese due to their whiter plumage, as opposed to Canada and white-fronted geese which are termed "dark" geese. The lesser snow goose occurs in two plumage phases: the white-phase ("snow") and darker ("blue") morph. Two populations of mid-continent light geese have been identified in North America and both occur mainly in the Central and Mississippi Flyways. The first migrates primarily through North and South Dakota, Nebraska, Kansas, Iowa, and Missouri, winters in Arkansas, Louisiana, Mississippi, and eastern and southern Texas, and is collectively known as the Mid-continent population (MCP) of light geese. The second population migrates through Montana, Wyoming and Colorado to winter in northwestern Texas, New Mexico and the Mexican state of Chihuahua, and is called the Western Central Flyways population (WCFP). The two populations are collectively referred to as Mid-continent Light Geese (MCLG).

During the past 30 years, the MCLG population expanded at a rapid rate. Estimates from mid-winter population surveys indicate the winter index of light geese had increased from approximately 800,000 birds in 1968 to more than 2.8 million in 1998 (U.S. Fish and Wildlife Service 1998). Refuges established in light goose winter range, coupled with waste grain from large-scale grain production in the Midwest, provided the goose population with ample forage and resting opportunities on migration and winter ranges. The MCP winter index increased five percent annually during the 10-year period from 1988 to 1997, and the WCFP increased an average of 9 percent annually during the same period (Abraham et al. 1996, U.S. Fish and Wildlife Service 1998). Surveys conducted during winter 1997 placed the winter index MCP of lesser snow geese at approximately 3 million and the WCFP at more than 215,000 for a total MCLG population of over 3 million birds. Projections put the breeding population over 5 million birds by the spring 2000 breeding season. The Central and Mississippi Flyways Councils jointly agreed to set lower and upper management thresholds for MCP lesser snow geese of 1 million to 1.5 million birds. As of February 1999, the MCLG population was 1.5 million to 2 million birds above this recommended threshold. At this rate of growth, the MCLG population was expected to approach 7 million birds within three years.

Environmental Impact of Light Goose Populations

The rapid increase of the MCLG population over the past 30 years has caused serious damage to their breeding range. Assessments indicate more than one-third of the breeding habitat in the Hudson Bay lowlands has been destroyed, with approximately 30 percent damaged and 35 percent overgrazed (Batt 1997). The fragile arctic environment, with its short growing season and slow recovery rate, cannot sustain continued impact of this nature and will likely result in loss of breeding habitat for many other species.

Some habitats in the winter range have also been damaged by the overabundant MCLG population. Vegetation loss due to light geese in coastal marshes in mid-Texas increased from four percent in 1939 to 21 percent by 1991 (Miller et al. 1996). Although revegetation occurred in some marshes, many reverted to open water. This damage was much less than that in the breeding range. The USFWS emphasized that their move to manage MCLG populations was not driven by habitat degradation of the winter range.

Grain production in the south central United States expanded during the 1970s and light geese benefitted from the increase in waste rice, wheat and barley available during winter and spring migrations. Geese return to their breeding grounds in good condition and with high stored fat, which promotes increased egg production and greater adult survival (B. Batt testimony before House Subcommittee, U.S. Congress, March 15, 1999). Although gosling survival rates have diminished, populations continue to increase because greater numbers of adults return to the nesting colonies. This population increase has lead to expansion of nesting colonies and concurrent degradation of additional breeding habitat.

Hunting and Light Goose Overabundance

Overabundant game species (e.g., resident Canada geese and white-tailed deer) generally occur where the use of hunting as a management tool is limited due to private land ownership or local ordinance (i.e., urban areas). The underlying problem with effectively hunting light geese, however, is not that they reside in urban regions but that their habits make them difficult for hunters to pursue. Unlike Canada geese, which will flock to spreads of a few dozen decoys, wintering snow geese fly in flocks of thousands of birds and require spreads of hundreds of decoys to attract them. Flocks of this size are also difficult to lure in gun range with two or three callers, which can be done with Canada geese. Added to the difficulty in attracting snow geese is the distribution of the flocks. Due to their habit of forming large flocks, snow geese are found in high numbers in some locations, but not at all in others. This makes it difficult for hunters not residing in areas of high snow goose concentrations (i.e., wintering grounds) to pursue these flocks.

Beginning in 1991 the USFWS attempted to address the problem of light goose overabundance by increasing light goose season to the maximum allowed by the Migratory Bird Treaty Act (107 days). Bag and possession limits were increased prior to 1991, and in 1998 possession limited were eliminated. These actions increased hunter activity and harvest, but the harvest rate (harvest divided by population index) actually declined due to the rapid expansion of the population.

New strategies are needed to increase light goose hunter activity and success. Surveys of hunters outside traditional snow goose migration routes and wintering grounds indicated that hunters lacked knowledge of light goose habits, thought large numbers of decoys were needed, and perceived a lack of access to lands where snow geese occurred (Miller 1999). A comparison of snow geese to Canada geese harvested in Illinois during the goose seasons prior to March 10 suggested snow geese were taken incidental to Canada goose hunting (Miller in preparation).

The Conservation Order

Need for the Conservation Order

By spring 1998 the overabundant lesser snow goose population had become such a threat to their breeding habitats that the Arctic Joint Goose Committee, a committee consisting of representatives from the Canadian Wildlife Service, the U.S. Fish and Wildlife Service (USFWS), and several non-governmental organizations felt additional population control measures were needed. To address this problem, the Joint Goose Committee proposed to reduce the MCLG population 50 percent by 2005.

The USFWS published a Notice of Intent on April 6, 1998 that stated the agency's intent to review of existing waterfowl regulations relative to light geese (63 Federal Register 16819). The notice also reported that the USFWS would conduct an Environmental Assessment (EA) as required by the National Environmental Policy Act (NEPA), including alternative actions and allowing public comment. The EA included use of electronic calls, allowing unplugged shotguns (more than three shells in capacity), hunting one-half hour before sunrise and after sunset, and no daily bag limits. The final EA, published February 10, 1999 reported a Finding of No Significant Impact for the proposed actions.

On February 16,1999 the USFWS published "Establishment of a conservation order for the reduction of Mid-continent light goose populations" as an additional step to control the light goose population in the Mississippi and Central Flyways (64 Federal Register 7517). This conservation order allowed take of light geese after March 10 (following the close of all other waterfowl and crane hunting), permitted the use of electronic calls, eliminated bag limits, and extended shooting hours to one-half hour after sunset. These rules took effect immediately upon publication. This was an extraordinary action on the part of the USFWS and showed how serious the agency viewed the snow goose overabundance problem.

The Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 ratified the Migratory Bird Treaty of 1916 between the United States and Great Britain (acting on behalf of Canada). Provisions of the Act included the establishment of refuges on waterfowl wintering grounds, setting of harvest quotas and prohibition of hunting beyond March 10 (Bean 1983).

At the time the Act was created and amended in 1918, waterfowl populations were in serious decline and several were in danger of extinction. Because unrestrained market hunting had seriously depleted waterfowl numbers, the Act was supplemented by other conservation measures (e.g., the Lacey Act) to encourage population recoveries. Further restrictions on methods of take were enacted during the next two decades, including prohibitions on use of electronic calls and limiting shotguns to three-shell capacity. Growing public concern for overharvest of wildlife lead to public demand for such measures.

Opposition to the Conservation Order

On February 22, 1999, a group of animal rights organizations, led by the Humane Society of the United States (HSUS), filed a suit against the USFWS in an attempt to block implementation of the regulatory changes (Humane Society of the United States et al. v. Clark). The suit alleged the conservation order was in violation of the Migratory Bird Treaty Act and NEPA. The HSUS further charged the conservation order could reduce the populations of the lesser snow goose and Ross' geese by up to 90 percent (Humane Society of the United States 1999). Through their suit the HSUS sought a court injunction to enjoin the USFWS from implementing the new regulations in the conservation order.

HSUS provided technical testimony that attempted to portray the problem as localized in nature and one that would be resolved in time through natural density-dependent regulation (V.G. Thomas testimony before House Subcommittee, U.S. Congress, March 15, 1999). Other testimony sought to show injury to waterfowl viewing enthusiasts by stating the reduction in population would deny them the opportunity to observe snow geese in their natural state (Humane Society of the United States, et al. v. Clark). The HSUS further stated that the intent of the conservation order was to bring the population within that recommended by the North American Waterfowl Management Plan.

Court Decision

The HSUS suit was filed in U.S. District Court in Washington, D.C. and heard by Judge Thomas Hogan. Although Judge Hogan ruled that HSUS had standing in the suit, he denied the injunction on the grounds that they failed to prove members of the HSUS would suffer irreparable harm if the injunction was not granted, that other parties would not be harmed if the injunction was granted, and that the injunction was in the public's best interest. The claim by the HSUS and others that the conservation order was in violation of the Migratory Bird Treaty Act was not supported. The conservation order was allowable under a provision of the Migratory Bird Treaty Act, which permits special action under extraordinary conditions where migratory birds cause injury to, among others, the agricultural community. The Court also refuted the claims of no ecological damage by the plaintiffs, stating that the testimony of one ecologist on behalf of the HSUS position was outweighed by the overwhelming evidence provided by more than 30 ecologists in the USFWS, Canadian Wildlife Service, Ducks Unlimited, the National Audubon Society and other non-governmental organizations.

The Court also indicated that, although the USFWS acted in good faith by completing the EA, the level of action in this matter required the completion of a full Environmental Impact Statement (EIS). Judge Hogan allowed the conservation order to stand for the spring 1999 hunt, but recommended the EIS process be undertaken. Accordingly, the USFWS began the EIS process and scheduled public hearings for fall 1999. The EIS procedure exceeded available resources and prompted the Service to hire a consulting firm to assist the Service with logistics, scheduling public meetings, and summarizing public comments required for the EIS process. As of this writing, the USFWS is completing the EIS process and plans to release it during summer 2000.

Outcome of the Conservation Order

Impact on MCLG Population

Eleven states took part in the conservation order during 1999. For many of these states the late date of publication of the regulations was such that they were unable to implement the changes to effect an optimal impact on snow goose numbers. Timing not withstanding, MCLG harvest during the conservation order was 342,771 (U.S. Fish and Wildlife Service unpublished data). These results are encouraging given the late implementation of the order did not allow states to make statutory changes necessary to implement all provisions of the order. For example, Illinois state law prohibited use of unplugged shotguns, which prevented the Illinois Department of Natural Resources from allowing hunters to use unplugged guns.

To ensure that the conservation order would be continued through spring 2001 (prior to completion of the EIS), Congress passed a bill on November 10, 1999, extending the light goose hunting provisions of the final rules and conservation order enacted in 1999. President Clinton signed the bill on November 24, 1999. This continuance gave states sufficient time prior to spring 2000 to change statutes that had prohibited full implementation of the order.

Impact on the Image of Hunters

The conservation order has raised some unique social as well as biological issues. Hunters are being asked, in a sense, to control nuisance species. This action is not unique in itself. Hunters in several states have been given more liberal regulations to harvest overabundant populations of white-tailed deer and resident Canada geese. However, critics have charged the manner in which the light goose hunting is being employed differs in many respects from the deeply ingrained traditions of conservation and fair chase (Reiger 1999). The USFWS has been accused of putting too much emphasis on harvesting geese at any cost, to the detriment of hunter ethics. Critics also claimed this action will harm the conservation image of hunters in the eyes of the public by promoting large kills of geese.

Suspending regulations prohibiting electronic calls, plugged shotguns and daily bag limits is a dramatic step and one that requires state agencies as well as the USFWS to draft carefully worded messages to hunters. The Fish and Wildlife Service made clear their intent to revoke the conservation order once management goals were achieved. State agencies have also followed suit. However, it is critical to fully communicate the intent of these actions for several reasons. First, hunters and non-hunters not knowledgeable of the snow goose problem may criticize the emphasis on large harvests and the use of hunting methods long considered to be those of the unethical hunter and poacher. Second, the allowable methods of take will be revoked after the conservation order expires. This means methods such as electronic calls will once again be illegal. In a study of goose hunters in Louisiana, Arkansas and Iowa conducted prior to the conservation action large majorities of hunters supported the use of electronic calls for hunting snow geese (Olsen and Afton 1999). Hunters in the study also responded they would likely increase their hunting participation if such calls were legalized. If new hunters are introduced to snow goose hunting by virtue of electronic calls, are these same hunters going to be retained after the current methods of take are prohibited? And if not, will we again find ourselves in a similar situation years from now whereby the harvest is unable to curb the increase in light goose populations?

Another issue that needs to be addressed is the perception among hunters of the ethics of the practices being employed. Suspending regulations is ethical if one considers the ecological cost. But what about the social costs? If young hunters are introduced to light goose hunting under the current regulations, what messages will these youths receive? Seasoned hunters aware of the problem may be able differentiate between the emergency situation and the status quo, but will this new approach to hunting have any lasting impression on new hunters?

An aspect of ethics that has not been addressed is the larger issue of using mechanical devices for waterfowl hunting. Devices that gave the hunter an overwhelming advantage were once viewed by most hunters as unsportsmanlike. However, recent sales of mechanical duck decoys and ongoing research indicate those attitudes may be changing (C. Miller unpublished data). It is likely that waterfowl hunters will see restrictions or prohibitions on mechanical decoys very soon, yet they will be permitted to use electronic calls for light goose hunting. Little research has been conducted to determine the typology of hunters who see these devices as fair chase. How will hunters perceive prohibiting electronic devices to harvest some species while promoting electronic devices to harvest others? We expect hunters to accept rescinding regulations following the conclusion of the conservation action, but anyone who has worked with organized hunting groups, particularly at the state level, knows that hunters do not always go quietly into the night.

Yet another social dimension that has not been examined is the emphasis on harvest. Considerable research has been conducted over the past 25 years that show harvest is not the primary factor in determining hunter satisfaction (see, e.g., Hazel et al. 1990, Vaske et al. 1986, Decker et al. 1980). Do hunter motivations for light goose hunting differ from other types of hunting? Are we witnessing a fundamental shift in hunter motivations driven by harvest? This point has been advanced in discussions on white-tailed deer hunting; perhaps the issue needs to be addressed in waterfowl hunting as well.

Wildlife managers have a responsibility to ensure that hunters, and especially the non-hunting public, understand that these actions are in response to an emergency situation, and in no way indicate a willingness on the part of regulatory and management agencies to compromise our long history of conservation. Our conservation practices have long sought to protect species and regulate hunter activity. In this case, we are trying to conserve more than a single species. We are attempting to preserve critical and sensitive habitat from overexploitation by a single species in order to avoid further impacts to many others, as well as protect the light goose population itself. This is the unique message we need hunters and the general public to hear. Thoughtful messages conveyed to media and, ultimately, the public that this action was urgent and needed to conserve a broad spectrum of wildlife. The difficult aspect of this message is that, in promoting the action, we are working for conservation by using practices we have long condemned. The population of light geese in the mid-continent has created an emergency situation and thrust management efforts into a new dimension. As managers, we must closely monitor this change in focus to ensure that lasting effects will not hinder new and innovative management actions in the future, nor damage the image of hunters and conservation. Extensive effort has been devoted to the ecological aspects of this problem, which is warranted given its ecological nature. Very little consideration, if any, has been given to the social dimension of the issue. We are seeking a social solution to an ecological problem. If we are to use hunting as the tool to solve this problem, we must understand hunter behavior in response to the issue. If we are to promote hunting as an ethical and responsible activity, we must convey the proper message to the hunting and non-hunting publics. This message can only be developed through understanding the issue in its social context.

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A Sportsmen's Task Force for Establishing Waterfowl Seasons

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Background

The New York State Department of Environmental Conservation (DEC), more specifically the Bureau of Wildlife, is charged with making season recommendations for waterfowl hunting in order to create recreational opportunities while protecting the resource. New York is unique in the Atlantic Flyway in that it has five zones for the purpose of waterfowl hunting season-setting. With habitat ranging from the Adirondack Mountains to the tidal marshes and ocean waters of Long Island, two Great Lakes, the Niagara, Hudson and St. Lawrence Rivers, Lake Champlain, and the Finger Lakes, it is not difficult to understand why we have sought to maintain several hunting season zones. Even so, the annual task of setting season dates within each zone has never been an easy process (Benson et. al. 1957). Hunters, of course, want to maximize their time afield and hope that the season dates for their particular favorite spot will somehow encompass the exact time that the peak of the migration occurs. But Mother Nature often disrupts the best-laid plans of mice and duck hunters, and that's an ongoing dilemma which won't be solved until humans can control the weather.

One given in the season-setting process is that the U.S. Fish and Wildlife Service annually establishes legal guidelines for the earliest and latest season dates, length of season, number of splits allowed, general bag limits and species-specific restrictions. Given these parameters, usually referred to as the "federal framework," choices of season opening and closing dates are basically social issues.

In the past, New York wildlife biologists and managers have conducted annual meetings with waterfowl hunters to share the latest information about breeding ground surveys, production estimates, the current season framework, etc. Many hunters would express diverse preferences for season dates and lengths of splits. Biologists also would attend meetings of organized waterfowl groups to share information and glean additional ideas for season preferences. Letters and calls to managers and biologists rounded out the sources of public input.

Armed with all this information, a regional wildlife manager from each zone would discuss the situation with his/her colleagues and devise the final Bureau of Wildlife season recommendation which was then submitted to the DEC Commissioner for final state approval. At that point, final acceptance by the U.S. Fish and Wildlife Service was usually just a formality.

In 1995, the regional wildlife managers turned the process over to a team comprised of state waterfowl biologists representing each of the zones, along with our central office waterfowl specialist, and one regional wildlife manager. This group was charged with maximizing "hunter satisfaction," but just what that is still eludes us. That year, they followed pretty much the same process as just described in establishing waterfowl season recommendation for the commissioner.

Unfortunately, even with five zones, there are still major differences in habitat from one end of a zone to the other. Factions arose in at least two of the zones where hunting season preferences differed because of significant differences in habitat, and peak abundance of ducks within the zone. There were regularly two or more groups whose ideas were at odds with each other. Catering to one group would antagonize the other. DEC seasons were, at best, a compromise designed to placate all the groups, but which often did not satisfy any of them. We were definitely in a "no-win" situation. The problem was especially evident from 1988 to 1993, when duck seasons in the Atlantic Flyway were only 30 days long and hunter preferences for dates extended from early October to January.

Process

In 1996, the time had come for getting hunters directly involved in the season-setting process. We decided to create a task force of hunters from the Western Zone, where we had experienced the most controversy and greatest dissatisfaction with seasons. The Western Zone includes nearly all of central and western New York. This zone includes most of Lakes Erie and Ontario and associated lowlands, the Niagara River, all the Finger Lakes, and a portion of the Appalachian Plateau. Some of our largest emergent marshes and managed wetland areas, including the Montezuma Wetlands Complex, occur in the lake plains. Deep water habitats which remain open all year abound in the Niagara River, the Great Lakes and the largest Finger Lakes. The Appalachian Plateau is a hilly area characterized by small beaver ponds and streams which freeze up early in the season. It is not unusual for the wetlands and smaller waters of a large portion of the zone to be frozen and nearly devoid of waterfowl, while fantastic hunting is going on at a few locations scarcely an hour's drive away.

The first step in creating a task force was to select waterfowl hunters who could represent the various hunting groups and who understood the major types of hunting areas. Every county in New York has a federation of sportsmen clubs that, in turn, comprise a regional and ultimately statewide, Conservation Council. Each regional council appoints a person to serve on the statewide waterfowl committee. The Western Zone encompasses all or part of three DEC regions, so the first three members of the task force were the Conservation Council Waterfowl Committee Representatives for those regions. Next, we asked each of the four major waterfowl hunting groups in the zone to select a representative to serve on the task force.

Seven seemed like a good number, but there was a problem. Some significant waterfowl hunting areas in the Western Zone, such as Chautauqua Lake, were not represented geographically by any of the seven members we had identified. It was decided that three or four more "at large" members would be necessary to adequately represent known constituents of the zone. They were identified by other group members or personally known by DEC biologists from those areas.

The final 1997 Western Zone Task Force had 11 members. All Task Force nominees were contacted in February with a description of the work to be done, and all eagerly agreed to serve. A single meeting was planned for them to complete their work.

A Cornell Cooperative Extension employee agreed to act as facilitator, and the group convened at a DEC regional office at 9:00 a.m. on April 19, charged with the responsibility of recommending dates for the 1997-98 duck hunting season. The state waterfowl specialist and several other DEC biologists attended the session. They were available to present the anticipated federal framework (i.e., 60 days; between October 1 and January 20; can split into two parts) and answer any technical questions which might arise, but did not participate in any other way with the process. For our part, we (the Bureau of Wildlife) agreed to accept the Task Force recommendations (assuming they reached an agreement), and pass them along to the DEC Commissioner for his approval. We advised them that we would select the season at a later date if they could not reach consensus.

For each discussion point (opening date, length of split, etc.), group members stated their opinion or the opinion of the stakeholders they represented. Discussion followed, and the Task Force was encouraged to reach decisions through consensus rather than to vote on each issue. Lunch was provided at a local restaurant—a needed break after three hours of negotiation and compromise. The Task Force reconvened at 1:00 p.m., and the meeting was concluded at about 4:00 p.m., with all work accomplished and a good feeling among everyone involved!

That summer, our waterfowl information meetings were interesting and very satisfying for us as we watched Task Force members, rather than DEC, present the final season recommendation to their peers. The audience was much less antagonistic, since hunters had hammered out the compromises with other hunters. Hunters and biologists agreed that, in spite of a few glitches, the process had worked well. Hunters asked that the process be continued the next year, which it was. Word of this success spread, and the process was expanded to a second zone the following year.

Discussion

The Task Force approach has been utilized in two of our waterfowl zones for three and two seasons, respectively. For the most part, it has been a successful process. The greatest shortcoming, as with nearly any process, is communication. The public has to know, first of all, that the season recommendations are being formulated by a task force of their peers. The notification process was definitely perceived by some hunters as a problem the first year, which is not unusual in the initial stages of any new project. Last year, the third year for this zone, communication seemed less of a problem. Second, the task force members' names and addresses must get wide circulation in advance of the meeting so that people can contact them to provide input. We published that information via news release, and task force members personally contacted clubs or stakeholders they represented. Some of them circulated surveys in an attempt to get input from additional hunters. In this way, many more people had direct input than before. Whereas only about a hundred provided input in prior years, well over a thousand had input in just the first year of the Task Force process.

So far, all task force members have been male. Our facilitator was a woman who worked at a local Cooperative Extension office. We felt that this was a definite advantage and an asset, rather than a liability, to our process. The men conducted themselves with more courtesy toward the facilitator and each other than we expected. In fact, we specifically chose another woman to facilitate meeting in the second zone using this process. We have experienced the same success in this regard as with the first group.

Another issue was the charge to reach agreement via consensus. Consensus means, simply, that although everyone may not agree exactly with a given decision, they can all "live" with it and support it. In theory, this would have given us better "buy in" from all involved. There was a definite tendency the first year, however, to vote on things, which was very difficult to avoid. In fact, the facilitator somewhat misunderstood her role in this regard, and actually added to the confusion. Since then, we have made it very clear in our charge to the Task Force and to the facilitator, that they are to work from consensus. The process has progressed more smoothly in subsequent years.

Despite the overall success, there have been growing pains and the inevitable criticism. Recently, some hunters have indicated they feel they are not being fairly represented by Task Force members. This is especially true of individuals not affiliated with any organized club. Task Force members are aware of this and are attempting to contact more of these individuals. Also, we have asked each of the three Regional Conservation Councils to nominate one or two "at large" members for inclusion on the Task Force instead of DEC finding them. Their nominees will hold the three or four additional slots originally identified to give the group "geographic" balance, so the group (task force) size will remain the same.

It is not easy to get waterfowlers from across a large area to agree on the optimal season for everyone. There are usually as many opinions as there are waterfowl hunters in a room. And, like other groups of sportsmen, they don't always trust the government. However, we strongly believe that this process in which they have been empowered to set the duck hunting seasons has been a great experience for them and for us. In general, their trust in us has increased. Their understanding of the complexities of waterfowl seasons has improved. They definitely appreciate the difficulties involved with satisfying a diverse group of constituents, and they are now feeling accountable for their decisions. We, in turn, have had the satisfaction of watching our idea bear fruit. We have all learned much, and we think the process will be especially helpful if or when seasons are ever cut back to 30 or 45 days.

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Session Four.
Hostile Takeovers in America: Invasive Species in Wildlands and Waterways

Chair
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Lakewood, Colorado

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Biological Invasions: Global Swarming is Heating Up

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An invasive species is a non-indigenous species that successfully reproduces after release in a non-native environment, and spreads (or is capable of spreading) its range until all accessible suitable habitat is occupied. The key component to this definition is that of inexorable spread; although rate of range expansion may be important from a management perspective, it is not in determining whether or not a species is invasive. Ecologically, rate of spread may be irrelevant because regardless of rate the end point of any invasive species' population expansion is the same, namely the colonization of all accessible suitable habitat. Thus, separated from our sense of time, the spread of European starlings (*Sturnus vulgaris*) from Central Park, New York to Alaska in little more than 60 years (Elton 1958:24) is little different than the 0.8 kilometer per year range expansion for Sika deer (*Cervus nippon)* on the Eastern Shore of Maryland (Feldhamer and Chapman 1978). Eventually, all accessible suitable habitat is occupied.

Rate of spread is important; however, in determining how quickly and how intensively control measures must be instituted to be effective against an invasive species. In fact, the time factor may be the key to thinking responsibly about invasions. Those that occur too slowly to be noticed by our temporal frame of reference may not elicit any reaction by ecologists or natural resource managers, nevertheless they may still be tremendously rapid by measures of ecological time. It is all a matter of perspective, and too many ecologists and managers can miss that perspective when forced to deal only with rapidly spreading invasions. A non-problem could really be a major problem, but humans are too short-lived to perceive it.

Elton (1958) described biological invasions as ecological explosions. He was, I believe, the first to allow that such explosions may develop slowly. I think that point has been missed in subsequent studies and descriptions of biological invasions. Every successful invasive species is, in fact, analogous to an explosion; range expansion of the invasive species is the shock wave that radiates out from the point of detonation. But every invasive species has a shock wave with a different velocity. Those with a rapidly dispersed propagule, such as zebra mussels (*Dreissena polymorpha)* or Russian thistle (*Salsola iberica)* are a rapid explosion. Those with a propagule that disperses only with difficulty and never very far from the maternal range, such as oaks (*Quercus spp.)* and sika deer (*Cervus nippon)* are an explosion in slow motion. If an invading organism has a slow rate of dispersal and a long generation time, it is conceivable that observers might not perceive an invasion occurring beneath their noses.

Pertaining to rate of invasions, we should keep in mind that humans (*Homo sapiens)* probably have been the most invasive species in the history of the planet. We have colonized nearly all of the terrestrial landmass (excluding Antarctica), caused widespread biotic perturbation and extinctions, and done all this with a rather low intrinsic rate of increase. In comparison with rates of reproduction and dispersal by which we sometimes judge invasibility, humans are quite inferior, yet the outcome of our global invasion from its origin in tropical Africa has been absolute.

Biological invasions can be costly. Invasive species are implicated in severe environmental disruption in a variety of ways, including alteration of rates and patterns of succession, depression of productivity or standing crop biomass, displacement or extinction of native species, reduction of biodiversity, and disrupted ecosystem processes and functions. They also are costly to human societies because of lost crop production, disease, lost production of desirable native species, and physical damage to natural ecosystems and human property. Dollar estimates for damages associated with invasive species in the United States alone are staggering. For example, the Office of Technology Assessment (OTA) (U.S. Congress 1993) estimated a minimum cost associated with the 79 invasive species in the U.S. to be at least $97 billion for the 85 year period (1906-1991). Alternatively, Pimental et al. (2000) estimated that invasive species cost the U.S. more than $137 billion per year, roughly two orders of magnitude higher than the OTA estimate.

Historical Perspective

The land area of the planet is generally divided into six zoogeographic regions characterized by marked faunal differences, and each of which represents the center of origin for some number of the taxa found in that region. These faunal regions are probably best known as Wallace's Realms (named after Alfred Russell Wallace), although Wallace (cited by Elton 1958) was not the first to recognize these patterns of animal distribution. The boundaries of Wallace's Realms are not all sharply defined and do not always follow continental margins. What is important is that these boundaries act as an impediment to natural dispersal between realms which have resulted in long periods of isolation. Of interest to this talk are the relatively shorter periods when isolating barriers break down and numerous taxa invade an adjacent realm. The results of such a dispersal event can be catastrophic for susceptible taxa, for example, the marsupial fauna of South America seems to have been decimated by dispersal events of North American placental mammals moving south across the Panamanian land bridge. Yet, in spite of such dramatic events that often were accompanied by significant extinction pulses, the mammalian faunal communities of the Nearctic and Neotropical realms (for example) are nevertheless recognizably distinct. This distinctiveness is testimony to the rarity of dispersal events between faunal realms.

Now, however, the zoogeographic rules have changed. Former barriers to natural dispersal are no longer effective against human-assisted transport of species. With the emergence of the human species as an ecological dominant, a whole host of organisms have evolved to exploit ever-increasing human-dominated environments and thrive in the disturbance characteristic of the human footprint on the land. Some organisms are intentionally moved between realms; others successfully stowaway in or on human goods or transportation. As

Elton (1958) warned, we are witnessing "one of the great historical convulsions in the world's fauna and flora," and it is resulting in the homogenization of the planet's biota. We surely are witnessing the most precipitous blurring of the lines between Wallace's Realms since before the breakup of Pangea, and it is a human-induced phenomenon.

By example, I work on islands with feral mammals, such as goats, pigs and sheep. These medium to large terrestrial mammals are quite incapable of long distance overwater dispersal. For reasons of energetics and water balance, they could not survive the long process of bobbing about on the ocean for weeks without food or potable water. Yet, the Galapagos Archepelago now is home to large numbers of feral goats, pigs and burros. The Hawaiian Archepelago is even farther from the nearest continental source of terrestrial mammals, but is equally devastated by these beasts that could not possibly have arrived by natural means.

Only in the past couple of millennia, and primarily in the last several centuries, have the natural barriers to dispersal by most organisms been breached regularly and unpredictably by human traffic, resulting in the unnatural spread of organisms, ecological upheaval and occasional pandemics. The oceans, mountains and deserts that helped create Wallace's Realms over millions of years have suddenly been rendered ineffective (Interantional Union for the Conservation of Nature 1999).

The fossil record aside, over time we clearly have had ample warning of the negative aspects of invasive species and diseases. Columbus and his crew brought smallpox to the western hemisphere on his first voyage; Spaniards brought it to Cuba soon after, and it has been speculated that smallpox then entered continental North America in indigenous people fleeing north from the Spaniards, perhaps resulting in 90 percent mortality of the entire North American human population by the time the pilgrims landed at Plymouth Rock (Kay 1998). On another note Darwin (1860) provided abundant examples and commentary on the spread and dominance of European species in non-native environments, such as pigs, horses, cardoon (*Cynara cardunculus*), and fennel (*Foeniculum vulgare*) in the pampas of Argentina, and later the nearly complete replacement of native plant species on St. Helena. It was at St. Helena that Darwin (1860) correctly deduced that goats had brought about the demise of the native flora and, thus, had "affected not only the land-shells, causing eight species to become extinct, but likewise a multitude of insects."

Predicting Invasions

It is practically an academic cottage industry to debate the predictability of any particular organism's potential for invasibility, and, similarly, the susceptibility of different habitat or community types to invasion. A parallel debate concerns whether or not disturbance is required for a community to be invaded. Unequivocal answers to these questions do not exist, but there are patterns that are abundantly clear for even disagreeing ecologists to see. The best starting point to this discussion was said best by Williamson (1996) : "An invader can be any sort of species going into any sort of habitat. All systems are, apparently, invasible."

It is likely that there are no natural areas not invaded by some species.

Usher (1988) reported that invaders had established in all 24 nature reserves studied, and the strongest correlate was with the number of human visitors to each area. We would do well to accept the notion that there is no place or habitat absolutely secure from biological invasion. We would likewise do well to adopt a prophylactic paranoia of thinking that every biological community is at risk.

There have been a number of significant efforts designed to refine the ability to predict correctly whether a species is likely to become an invader or not. Models to predict invasiveness must, by necessity, be retrospective in order to provide validation. One cannot validate predictive power based on species not introduced, and it would be irresponsible to validate a model by introducing new species that might successfully become invaders and cause detrimental ecological effects. Although a good model might correctly predict invasiveness for a majority of successful invaders—e.g., 80 percent (Reichard and Hamilton 1997)—some species are missed and probably will always be missed. Reichard and Hamilton (1997) found that the best predictor of a species invasiveness was whether it had invaded elsewhere.

In addition to demonstrated invasiveness elsewhere, there are a number of criteria that might be used to predict invasiveness, such as taxonomic relatedness to species known to be invasive, weedy characteristics such as rapid maturation, high reproductive rate, dispersal rate or capability, ability to reproduce vegetatively, and many others. Using these criteria will likely identify most potentially invasive species, but again, the criteria of invasiveness rely on an undefined temporal scale where invasiveness is perceived as a rapid increase in number and expansion of range. While these rates are important in determining our response, they may not be relevant concerning the endpoint of the invasion.

Clearly, the highest risk species for invading are those that are weedy in nature (plants and animals). Such species usually have high rates of reproduction and reproduce at an early age, disperse rapidly and successfully colonize disturbed habitats. These life history traits mesh smoothly with the fact that most terrestrial and aquatic environments as we begin the 21st century are part of a human-influenced landscape. Basically, most of the planet now has, at least in part, a human-influenced disturbance regime; disturbance is perhaps the major feature of human dominated landscapes. Beyond these generalities, biological invasion is pretty much a crap-shoot. We're pretty good at correctly predicting most species capable of invasion, but there are always some in the wings that we would have no reason to suspect.

While we can logically argue that most environments have been disturbed, at least slightly, by humans, it is equally correct that undisturbed environments simply do not naturally exist. Disturbance encompasses events along a continuum of scale ranging from something as localized as a single tree falling in a forest, to the effects of a major wildfire or flooding event. Human activity has certainly changed the frequency of disturbance at the lower end of the scale, and the scope of disturbance events at the upper end of the scale (desertification and deforestation). Humans may even cause disturbance in a system by trying to limit natural disturbance regimes. For example, river systems that regularly undergo large scale flooding as a natural event usually have organisms that evolved to thrive and depend upon that level of disturbance. When humans control such disturbance events, invasive species may be favored by the new "kindler-gentler" disturbance regime. In essence, the interference with natural disturbance regimes can be a dramatic perturbation to the structure and composition of a landscape. It would seem human treatment of the landscape is destined to favor invasive species.

Of course, any predictive capability to determine which species will ultimately prove to be invasive is a wasted effort if the ability to prevent entry of potentially invasive species is limited by insufficient inspection or the failure to prohibit them. More than 750 potentially invasive species meeting the listing criteria of the Federal Noxious Wed Act remained unlisted when OTA prepared its report (U.S. Congress 1993).

Effects of Invasive Species

The Living Dead

Any successful invasion guarantees perturbation; for some invaders this perturbation will be severe. Some successful invaders guarantee extinction of one to many native species, virtually from the moment they are released and begin their inexorable spread. What is important to consider, and to never lose sight of, is that these effects may not be immediate, but they may be end points occurring as much as several centuries in the future, and therein lies one of the greatest impediments to taking action against invaders when first noticed. It is only with great difficulty that a control program might be funded and carried out in response to an invader whose possible ultimate effects may not be attained for several human generations. This is not the kind of crisis that land and natural resource management agencies are prepared to deal with, either by budget or vision.

An example of such a scenario that I am familiar with is the effects of feral goats on several oceanic islands. The typical scenario as I have described it (Coblentz 1978) is a series of stages beginning with overutilization of favored plant species and ending with severe erosion, reduced productivity, and eventually a significant extinction event because the goats consume all of the potential seedling regeneration of numerous species. When the seed source of a species is gone and the adult trees (shrubs, forbs, etc.) are not replaced, the species is extinct. This is similar to what Darwin (1860) reported when his voyage home on the Beagle stopped for a time at St. Helena in the South Atlantic. In the case of St. Helena, it took roughly 200 years of herbivory by goats, likely the maximum lifespans for many of the endemic tree species, before these species were extinct and the "evil was complete and irretrievable."

Similarly, there are feral goats in the Galapagos today that have severely altered community structure and ecosystem processes, but have yet to cause wholesale extinction. However, an extinction event looms just around the corner because the maximum lifespan of many of the tree species is being approached, and eventually they will all die from old age-related natural mortality. When this occurs, if we allow it to happen, the extinction will accelerate into a number of interrelated cascades, and the system will forever be different. In the case of the Galapagos, those trees at higher elevations that will eventually vanish due to goats are also the physical habitat for a rich and highly developed assemblage of epiphytic plants that continuously captures fog moisture during the garua (fog) season and causes it to drip to the ground as if it were raining. The entire community is dependant on this season-long moisture input; the tortoises (*Geochelone elephantopus)* depend on fog drip to form pools under trees in which they wallow and avoid overheating in the afternoon sun. As the mature trees die of old age or overbrowsing, and no seedlings survive to replace them, less fog moisture will be intercepted and eventually the highlands are transformed from lush communities to a seasonal dustbowl of greatly reduced productivity. The endpoint of this scenario, were it to proceed, would be a system of reduced biodiversity having lost a number species from trees to epiphytes to invertebrates and, perhaps, eventually to the tortoises that may have been the keystone herbivores in the pristine Galapagos. All those species eventually lost were the living dead. They were extinct from the moment goats were introduced, but neither they nor we knew it until the scenario had played out for decades, centuries or longer.

Extinction Debt

The living dead are the payments a system has to make when reaching a new equilibrium caused by a successful biological invasion. This is extinction debt. There is a relationship between island area (or habitat patch size) and the number of species of a taxon that can live in that area (MacArthur and Wilson 1967). Numerous examples, primarily of birds, exist where a number of species adjusted downward as the size of contiguous habitat patch was decreased (Barro Colorado Island [Willis 1974], Bogor Botanical Garden [Diamond et al. 1987], Brazil Forest fragmentation studies [Lovejoy et al. 1986]). In other words, a habitat patch of a given size should only have a certain number of species, and it seems a reasonable assumption that additions of species to a system, if they are successful (invasions), will cause some already existing species (or several) to at least become locally extinct, or completely extinct if endemic only to the area in question. Thus, biological invasions are likely to cause extinctions, but these extinctions will not be immediate. It may take years, decades or even centuries for a new equilibrium to be reached, but some extinctions are a strong likelihood. This lag effect results in a backlog of extinctions-to-be. Some extinctions may be predictable, and some not, but they probably will occur. In simple terms, in a system containing successfully invasive species, there are doomed species (the living dead) whose fate may not yet be clear to us. When the last individual of a doomed species dies, the debt has been paid.

According to Cox (1999) more than 6,500 exotic species have invaded North America. A question every natural resource manager needs to ask is how many of the endangered species we have identified are really living dead that represent, at least in part, the debt to be paid due to the presence of so many successful invasives in their habitat.

The New Keystone on the Block

Keystone species are those species that by function, number or biomass are necessary to the maintenance of character and functioning of an ecosystem. If a keystone species is eliminated, or even severely reduced (in function, number, or biomass), a variety of predictable and unpredictable cascading effects are set in motion, and the resulting ecosystem will eventually end up dramatically different and perhaps less diverse. Essentially, the ecosystem moves along some trajectory at some rate until an altered stable system is reached.

In contrast, a roughly similar set of predictable and unpredictable cascading effects in an ecosystem, eventually leading to greatly changed character, function and diversity can be the result of an invasive species usurping a significant amount of space, nutrients or function in a non-native environment. In essence, an invasive species is a "negative keystone" species because through its invasion of an environment it has had a detrimental effect on the populations of native species, rates and patterns of succession, trophic linkages, and any of a whole array of possible biotic and ecosystem processes which combine to eventually result in a new, greatly altered, stable system.

The concept of the negative keystone species is really quite simple. It simply recognizes that the injection of an invasive species into a system might set in motion the kinds of large scale changes that can result when a keystone species is removed from a system. By way of analogy, jamming a steel rod into a car's transmission, or the removal of the transmission's spline gear, can have a very similar system-wide effect.

Back to the Future

Homogenization of biotas worldwide and the extinction events almost certain to occur as a result, will surely shape the course of future organic evolution. By causing the introduction of invasive species, or simply failing to control them after introduction, we are *de facto* eliminating endemic species from environments in all parts of the world. The end result to be played out over the next few million years is that we are diminishing the options for future evolution. Rather than proceeding with a rich diversity of organisms, many of which have evolved to specifically exploit unique conditions and environments, future evolution will involve a more limited diversity of organisms that share the single trait of being able to succeed in a human dominated landscape. The only way to ensure that the planet's biota can proceed along evolutionary paths that might have been (some would argue should have been), would seem to be to return as far as possible or practicable to communities as they were prior to invasion. Such a return to the potential future will obviously require control of invasives.

Dealing With the Problem of Invasive Species

The number of non-indigenous species in the continental United States (more than 6,576) and Hawaii (more than 4,598) (Cox 1999), or as many as 50,000 (Pimental et al. 2000), should seem staggering to anyone concerned with preservation of native biotic communities, yet they continue to arrive. Although only a minor proportion will ever reach serious pest status (The "Tens Rule" [Cox 1999]), each one is like a ticket in the lottery; each has an unpredictable outcome. The most stringent policy approach toward non-indigenous species is the "clean-list," essentially maintaining a zero-tolerance approach toward all organisms not specifically exempted by inclusion on the clean list. The reality of the problem is that regardless of clean lists, dirty lists, gray lists (U.S. Congress 1993) or anything else, non-indigenous species continue to arrive by accident, by intent and by disregard, and we still have the burden of intercepting them as they enter our jurisdiction.

By reasoning of most experts, prevention of introductions, although difficult, is more cost effective than control after the fact, and should be given the highest priority (International Union for the Conservation of Nature 1999). In addition to the simple difficulty of detecting potential invasive species at our borders, impediments to effective prevention of introductions are diverse and primarily stem from business concerns, for example, from the pet and horticulture industries.

Once released and established, most invasive species can be controlled only with great difficulty, if at all. The majority of successful invasive species are pre-adapted to be spread through human activity and land use. Many of the most successful invasives are those we describe as weedy (favor disturbance), and most human activity on the land involves disturbance. For example, roads are disturbance corridors regardless of the habitats they pass through; such a corridor functions as a means of dispersal and spread for those weedy species and, by this means, invasive weeds can penetrate an otherwise undisturbed environment.

The pathways by which invasive species may be introduced and spread are multitudinous and diverse. Propagules may be spread by wind, water, motor vehicles, animal pelage, animal feed (or in the gut of animals) and even in the cleats of hiking boots of ecotourists (and scientists) who might never imagine the damage they could cause by not cleaning their boots thoroughly between excursions. In commerce, organisms, including parasites and diseases, may be introduced in hay, commercial seed, packing material (including green wood), logs, nursery stock, live pets, and a host of other obvious possibilities including ballast of commercial ships.

Exotic species pose a regulatory nightmare. The first hurdle is to identify those species that are potentially invasive, but as mentioned above, a potential invader might be just about any species. Assuming we could move to a clean list approach, we then need to identify all of the direct and circuitous avenues through which and by which invasive species might be transported. Assuming this could be accomplished, we need management capability facilitating detection and interception, and then finally need management authority and capability to act swiftly and decisively to contain any outbreak resulting from an invader that somehow makes it through, assuming we can judge the likelihood of success as being probable. When considering eradication we need to choose our battles carefully, and above all else, quickly. Once an invader has become widespread and numerous, chances of successful eradication may be slim. Eradication is most effective when an invader is first discovered, thus the need for a rapid response capability. If the likelihood of reinvasion is very high, eradication is not likely to be a cost-effective nor a very successful option.

On February 3, 1999, President Clinton signed Executive Order 13112, "to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause. . . ." Executive Order 13112 says all of the right things. It directs federal agencies to prevent introduction of invasives, detect those that slip through and respond rapidly to control them. There are directions to monitor invasives, provide for restoration of native species and habitats and conduct research on the invasives themselves and technologies that can prevent or control them.

The only hitch seems to be in Section 2(a) where the entire executive order hinges upon "to the extent practicable and permitted by law." A congressperson and an ecologist might differ considerably as to what they thought was a practicable solution to an invasive species problem. In this regard, it is worth considering that an Executive Order is not actually law, but rather, an "Executive interpretation of available — and often highly ambiguous—legal authority" (M. Miller personal communication: 1999).

Looking Into the Future

In the past several centuries we have not done a very good job of maintaining the integrity of biotic communities. On a global scale, most environments have been penetrated, and many dominated, by invasive species ranging in size from viruses to water buffalo (*Bubalis bubalis*). While many species have been excluded from entering our borders, others pass through, seemingly with impunity. As yet, we have not done a very distinguished job of preventing pathogens, insects, zooplankton or plant seeds from crossing our borders, and it is likely that new ones will continue to enter. One can never predict where the next plague might originate or how it might arrive. Even with our relatively precise predictive capability we find it quite impossible to prevent the spread of each year's new strains of the influenza virus from crossing our borders.

How might the 21st century appear to an ecologist? In the absence of concerted efforts to prevent, intercept and control invasive species, North America in the next century will look a lot more like the other continents, especially Europe and Asia. Were all of the provisions of Executive Order No. 13112 to be funded and implemented, then we would surely face a multitude of special interest and animals rights groups that would argue, lobby, and sue to protect their ability to import potentially invasive species, or to prevent certain invasive species or just animals and plants in general from being killed. The evolving World Trade Agreements may prove ecologically costly in that we may find our doors pried open to the risk of future invasions, however, illogically, in the name of free trade. The bottom line is that if one is to live in North America in the 21st century, it would help to be particularly fond of zebra mussels and starlings. If one was particularly fond of stately American elms (*Ulmus americana*) or butternut (*Juglans cinerea*) the next century could be a pretty bleak time to live. The unfortunate reality is that much of the bleak side of such future-casting is essentially guaranteed; on the other hand, we still have most of our biota and habitats that can be preserved, and the time to assure their preservation has already arrived.

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The Round Goby (*Neogobius melanostomus*): Another Unwelcome Invader in the Mississippi River Basin

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Transoceanic shipping ports along the Atlantic and Pacific coasts of North America have long been focal points for the initial entry and dispersion of a variety of nonindigenous aquatic taxa to coastal ecosystems of the United States. Public awareness of the complementary role that inland ports play in the distribution of exotic species to environmentally sensitive freshwater ecosystems of the mid-continent has been heightened in recent years by the introduction of an increasing number of aquatic nuisance species to the Great Lakes. This list of new and invasive taxa includes several species of invertebrates—zebra mussel (*Dreissena polymorpha*),quagga mussel (*D. bugensis*), New Zealand mud snail (*Potamopyrgus antipodarum*), spiny water fleas (*Bythotrephes cederstroemi* and *Ceropagis pengoi*)—and fish—ruffe (*Gymnocephalus cernuus*), round goby (*Neogobius melanostomus*), tubenose goby (*Proterorhinus marmoratus*). These organisms were released into U.S. waters with untreated ballast water discharged by ships from foreign ports.

In response to the growing economic costs and ecological concerns raised by the introduction and rapid spread of zebra mussels in the Great Lakes and adjacent aquatic ecosystems, Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (Public Law 101-646). This legislation addressed the growing problem of unintended aquatic nuisance species introductions (e.g., zebra mussels) in the Great Lakes region by seeking improved management of ballast water discharges and encouraging the development of methods to control other transmission pathways. The scope of this act was broadened in 1996 when Congress amended and re-authorized it under a new title, the National Invasive Species Act (Public Law 104-332). This act placed a greater emphasis on aquatic nuisance species prevention and control efforts to better protect all U.S. water resources (Cangelosi 1997, Glenn and LaTourette 1997). Among the several nonindigenous aquatic species (NAS) introduced to the Great Lakes in the past decade, the round goby is currently considered one of the most serious threats to aquatic ecosystems of mid-America because its geographic range has started to expand into the Mississippi River basin. The round goby thus presents a challenging test case for federal, state and municipal authorities, private industry and public interest groups, as they work together to successfully implement laws and initiatives to prevent and control the spread of aquatic nuisance species around the country.

This paper will review and briefly highlight (1) the role of the Illinois Waterway System as a pathway for the transmission of NAS between the Great Lakes and Mississippi River basins, (2) the introduction of zebra mussels to the Mississippi River basin and some of the environmental consequences, and (3) the more recent introduction of round goby to the Mississippi River basin and strategies to diminish its continued spread here.

Clean Navigable Waters Aid Dispersion

The development of regional water transportation systems and continuing improvements in surface water quality during the past century have made many freshwater ecosystems across North America vulnerable to the introduction and establishment of NAS. Opportunities for NAS to translocate widely in freshwater ecosystems of the U.S. has long been aided (in part) by canals that have interconnected continental drainages. For example, the Illinois and Michigan Canal in Chicago first linked the Mississippi River basin with the Great Lakes basin in the mid-19th century. Other canals built more recently here now form the Illinois Waterway System (IWS), which not only facilitates the waterborne shipment of bulk commodities to regional, national and international markets, but also permits NAS to passively drift or actively emigrate from one basin to another. Commodity shipments on this waterway, as well as other types of commercial and recreational boating activities, increase the probability of unintentionally translocating a NAS from one river reach or drainage basin to another. These organisms can be transported in bilge water, on hulls, engine components, mooring lines, chains, anchors, live wells, boat trailers, and a host of other navigational components and recreational equipment.

The ability of many NAS to persist, thrive and expand their range in freshwater ecosystems around the U.S. also has been facilitated by recent nationwide improvements in surface water quality. As early as the mid-19th century, untreated sewage containing high levels of nutrients and suspended solids was discharged from numerous point sources in rapidly growing cities of midwestern U.S. (Mockovak 1990, Changnon and Changnon 1996). The biochemical oxygen demand created by these inputs would periodically overwhelm the assimilative capacity of receiving waters, creating virtually anoxic conditions in which only the most pollution-tolerant of aquatic taxa and virulent pathogens (e.g., *Salmonella typhosa*) could survive. In addition to excessive nutrient loading, the volume of industrial effluent containing persistent toxic substances continually increased during the industrial boom of the late-19th and early 20th centuries. As a consequence, portions of many urban surface waters were little more than open sewers and unsafe for human contact.

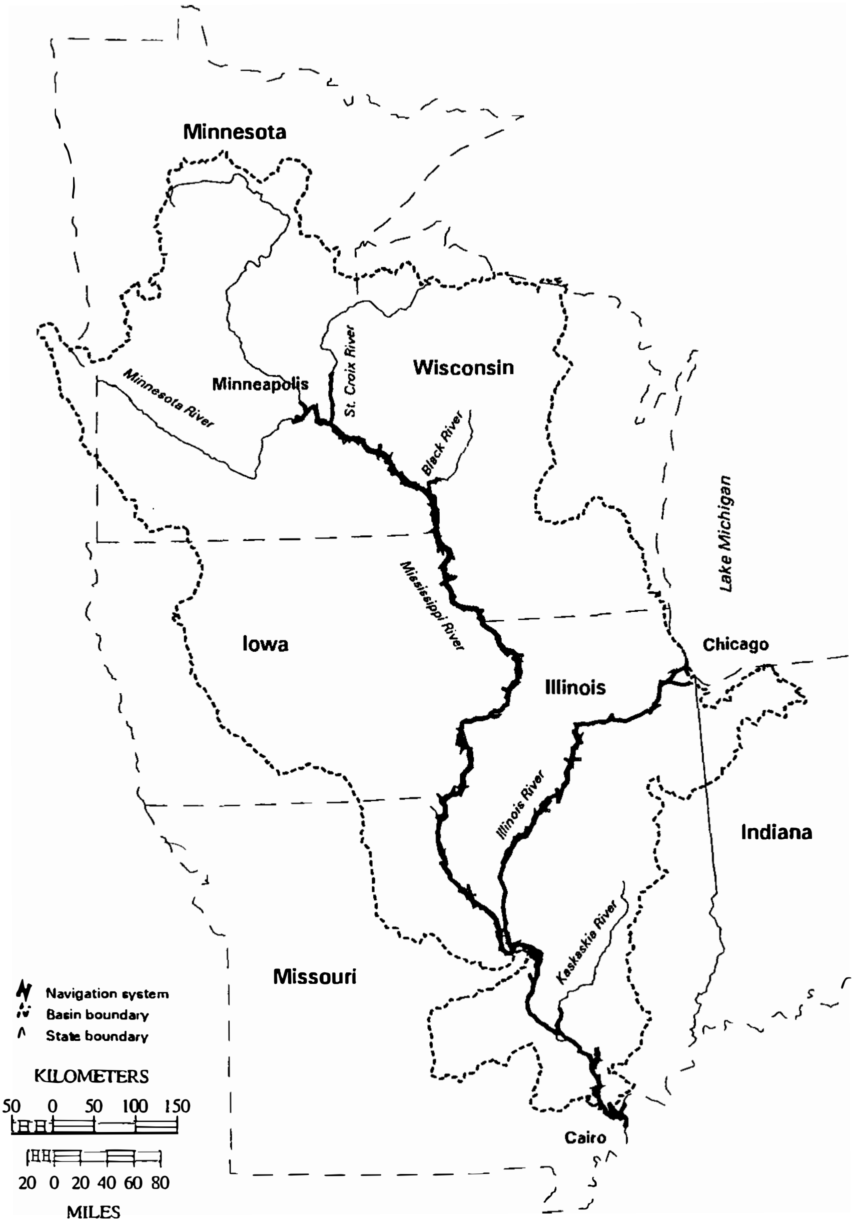
In response to several major waterborne disease epidemics during the late-19th century, urban planners around the country initiated a series of new wastewater treatment practices to improve local surface water quality. In Chicago for example, the normal flow of a drainage that transported untreated sewage to Lake Michigan, the drinking water source for the city, was permanently reversed in 1900. This engineering feat permitted water from Lake Michigan to dilute and flush the sewage from this stream into recently excavated canals that flowed downstream into the Des Plaines River. The link that these man-made canals provided for commercial navigation between the Great Lakes and Mississippi River basins was considered an added benefit of this waste treatment option and helped to advance this strategy over several others (Changnon and Changnon 1996). However, the dilution approach was inadequate to meet the sanitary regulations of this rapidly growing industrial city and was soon supplemented by a sewage treatment program that utilized newly developed and more effective technologies (e.g., sprinkling filters, settling basins, activated sludge).

More recent national improvements in wastewater and stormwater treatment, as well as a uniform permit system to regulate the discharge of conventional and toxic pollutants from point sources, were federally mandated by the Clean Water Act of 1972 and its subsequent amendments. This legislation is acknowledged as a major driving force that has significantly improved the water quality of rivers and lakes across much of the country. As a result, some species of native aquatic fauna (e.g., *Hexagenia* mayflies, unionid mussels, fishes) have recently expanded their distribution by reclaiming traditional habitats from which they were excluded by pollutants for decades (Fremling 1989, Fremling and Johnson 1990, Krieger et al. 1996, Dennison et al. 1998, Whitney and Blodgett 1999). However, improved water quality conditions may not be entirely to the benefit of certain native aquatic fauna should it reduce or eliminate a barrier that may have been limiting the spread of more competitive, opportunistic NAS.

The Zebra Mussel: An Alarming Wake-up Call

The operation and maintenance of a nine-foot navigation channel on the Upper Mississippi River System (UMRS) and its connection to Lake Michigan via the IWS (Figure 1) has recently helped expand the range of several NAS from the Great Lakes to distant portions of the Mississippi River drainage basin,

Figure 1. The upper Mississippi River drainage basin and navigation system (courtesy of the U.S. Geological Survey, Onalaska, Wisconsin). Note: the navigation system includes the upper Mississippi River from Minneapolis, Minnesota to Cairo, Illinois, the Illinois River, the Chicago are waterways, and the commercially navigable portions of the Minnesota, St. Croix, Black and Kaskaskia Rivers.



and vice-versa, by several modes of transmission (Table 1). The zebra mussel, a mollusc native to the Black and Caspian Seas of Eurasia, is currently the most widely distributed of these exotic species to have translocated from the Great Lakes to the Mississippi River drainage basin.

Zebra mussels were originally introduced to the Great Lakes in ballast water discharges from transoceanic ships in the mid-1980s and, by 1991, had spread by various means to several distant portions of the Illinois and upper Mississippi Rivers. The first sighting of zebra mussels in the upper Mississippi River (UMR) occurred near La Crosse, Wisconsin in 1991, approximately 475 river miles (764 km) upstream of the Illinois River confluence near St. Louis, Missouri. Additional sightings the following year further upstream, as well as in portions of several other navigable Mississippi River tributaries (e.g., the Ohio, Tennessee, Arkansas, and Cumberland Rivers) suggested that zebra mussels were being dispersed throughout much of the Mississippi River basin by routine navigation activities. This was confirmed by reports of live zebra mussels attached to barges that had traveled distances of up to 20,000 miles (32,180 km) in a 16-month period, distributing them to portions of the upper Mississippi, lower Mississippi, Illinois, Arkansas, Ohio, and Kanawha Rivers (Keevin et al. 1992, U.S. Army Corps of Engineers 1993). Routine maintenance inspections of tow boats operating in the Mississippi River System also find that recesses in the boat hull (e.g., sea chest, keel cooler) are common sites for zebra mussel attachment and long-range transport (Allen 1998). Likewise, submerged components of the propulsion and stabilization systems on large recreational watercraft provide suitable sites for zebra mussel attachment and redistribution in the UMR and adjoining navigable tributaries (S.T. Yess personal communication: 1998). The range of this invasive mollusc has continued to spread upstream, as well as downstream, within the Mississippi River drainage basin and now extends as far west as the Arkansas River in Oklahoma.

The rapid expansion of zebra mussel populations in the Mississippi River basin quickly altered many of the normal ecosystem functions, resulting in a range of adverse impacts to native species. Much of this stems from the remarkable filtering capabilities of zebra mussels which can significantly affect localized water quality. Typically, high densities of zebra mussels result in high water clarity, low phytoplankton levels, an enriched supply of available nutrients, and dissolved oxygen undersaturation (Effler et al. 1996). Reports of unusually low mid-summer dissolved oxygen concentrations (e.g., < 5 mg/L) at main channel sites in the UMR have become more common in recent years and have been associated with the respiratory demands of dense zebra mussel populations nearby (Sparks et al. 1994, Sullivan and Endris 1998). Severe oxygen depletions could change the composition of the benthic invertebrate community to more pollution-tolerant taxa, alter local food webs and quickly set back years

Table 1. Characteristics of several nonindigenous aquatic species recently introduced to the Upper Mississippi River System (UMRS).

Nonindigenous aquatic species recently introduced to the UMRS	Origin and year of introduction to the UMRS	Primary means of range expansion in the UMRS	Control strategy
Ctenopharyngodon idella (grass carp)	Aquaculture releases in the southcentral US (1970s)	Density-dependant emigration	Commercial harvest
Daphnia lumholtzi (spiny water flea)	Interbasin water transfers in the southcentral US (1995)	Transported actively by vessels and passively by water currents	Public education and integrated pest management
Dreissena bugensis (quagga mussel)	Ballast water discharges in the Great Lakes (1995)	Transported actively by vessels and passively by water currents	Public education and integrated pest management
D. polymorpha (zebra mussel)	Ballast water discharges in the Great Lakes (1991)	Transported actively by vessels and passively by water currents	Public education and integrated pest management
Hypophthalmichthys nobilis (bighead carp)	Aquaculture releases in the southcentral US (1970s)	Density-dependant emigration	Commercial harvest
H. molitrix (silver carp)	Aquaculture releases in the southcentral US (1970s)	Density-dependant emigration	Commercial harvest
Lythrum salicaria (purple loosestrife)	Horticultural introduction (early 20th century)	Wind, water, and wildlife mediated seed dispersion	Public education and integrated pest management
Morone americana (white perch)	Emigration from the eastern to the western Great Lakes (1990s)	Density-dependant emigration	Public education and integrated pest management
M. saxitalis (striped bass)	Aquaculture releases in southcentral US (1970s)	Density-dependant emigration	Public education and integrated pest management
Myriophyllum spicatum (Eurasian watermilfoil)	Aquacultural introduction (latter 20th century)	Stems fragmented and transported by vessels, wave action, and currents	Public education and integrated pest management
Neogobius melanostomus (round goby)	Ballast water discharges in the Great Lakes (1993)	Density-dependant emigration; also may be transported by vessels	Public education and integrated pest management

of ecosystem recovery efforts that were attributed to improvements in water quality (Sparks et al. 1994).

Zebra mussels also assimilate a variety of persistent contaminants as they filter-feed on suspended particles. A variety of native fish and wildlife species may thus be linked to zebra mussels in UMRS food webs, ultimately increasing the risk of enhanced contaminant transfer to and biomagnification among members of higher trophic levels, especially in areas with existing contaminant concerns (Steingraeber et al. 1994, Cope et al. 1999). For example, diving ducks may increase their risk of exposure to toxic contaminants by feeding in areas where zebra mussels are abundant and remaining there for extended periods during seasonal migrations (Wormington and Leach 1992, de Kock and Bowmer 1993). Likewise, elevated concentrations of polychlorinated biphenyls in smallmouth bass (*Micropterus dolomieui*) recently collected near Lake Michigan's Chicago shoreline (T. Hornshaw personal communication: 1998) may be due, in part, to their predation upon a locally expanding population of round goby, which will preferentially feed on zebra mussels (Ghedotti et al. 1995).

Of the ecological consequences that may result from the establishment of zebra mussels, one of the greatest concerns is for adverse impacts to the native benthic fauna with which they directly compete for available resources. The impacts that zebra mussels are having on the diverse native mussel fauna in the Mississippi River basin has been focus of much attention. Like coral reefs in the ocean, native freshwater mussel beds in the UMRS help to create unique ecosystems that support a diverse variety of native fish and wildlife species. Unfortunately, native mussel beds are also one of the primary natural hard substrates available for settlement and attachment of zebra mussel veligers in the UMRS. Zebra mussels colonize the shells of all species of unionid mussels and may reduce both the abundance and diversity of native unionid communities by a variety of physical mechanisms (Mackie 1991). Therefore, zebra mussels represent a serious threat to the survival of several state and federally listed endangered or threatened mussel species in the UMRS (D.L. Strayer personal communication: 1998).

The Round Goby: A Call to Action

The round goby, like the zebra mussel, is native to the Black and Caspian Seas of central Asia and was probably introduced to the Great Lakes in ballast water from transoceanic shipping in the late-1980s (Marsden and Jude 1995). This small, aggressive benthic fish was first reported in the U.S. in the St. Clair River, along the Canadian border, in 1990 (Jude et al. 1992). By 1993 the distribution of round goby had expanded to several Great Lakes' ports (presumably as a result of ballast water exchanges by inter-lake shipping activities) and they are now present in all the Great Lakes. Meanwhile, the round goby population in southwestern Lake Michigan was beginning to expand inland on Chicago's south side via the Calumet River.

A combination of aggressive behavioral traits and prolific spawning abilities give the round goby a distinct competitive advantage over most native species of bottom-dwelling fishes. Round goby may be largely responsible for the decline of mottled sculpin (*Cottus bairdi*) and logperch (*Percina caproides*) populations reported in the St. Clair River during the mid-1990s (Jude and DeBoe 1996). These findings have created concern regarding the potential effect of round goby on functionally similar species of native fish (e.g., darters, sturgeon) that inhabit the Mississippi River drainage basin (Exotic Species Program 1998). Likewise, the dietary preference of round goby for zebra mussels (Ghedotti et al. 1995) is disturbing as it could enhance the transfer of contaminants in the UMRS to piscivores at higher trophic levels (Exotic Species Program 1998). Moreover, most of the habitat rehabilitation and enhancement projects (HREPs) completed along the UMRS in the past decade have used rock riprap to stabilize both newly created and existing river banks (K. Beseke personal communication: 1998). The complex network of interstitial spaces provided by this material is the type of habitat most preferred by round goby in near shore riverine environments (Jude et al. 1995, Jude and DeBoe 1996). This rock also provides attachment surfaces for zebra mussels, an important food item for larger round goby (Ghedotti et al. 1995, Jude et al. 1995). Therefore, if round goby penetrate beyond the Chicago area waterways and further into the UMRS, HREP riprap may provide a longitudinal series of "stepping stones" for its expanded distribution within this drainage basin.

The extent to which navigation activities and water discharges may enhance the downstream distribution of round goby in the Chicago waterways toward the Illinois and Mississippi Rivers is unknown. Yet the recent introduction of round goby from the Volga River upstream into the Moscow River in central Russia may have resulted, in part, due to the transport of goby egg masses on barge hulls through channels connecting these drainages (Sokolov and Tsepkin 1992, Tsepkin et al. 1992, Sokolov et al. 1994, Moskal'kova 1996). Thus commercial vessels plying the Chicago area waterways could be vectors for the transport of round goby to other navigable portions of the Mississippi River basin. In addition, the great variety and number of recreational vessels that moor in and pass through goby-inhabited waters here could also contribute to goby range expansion in the UMRS.

The home range behavior of the round goby may help to limit the "unaided" extent of its downstream distribution in the Mississippi River basin. Individuals at the leading edge of its range may be hesitant to seek out new habitat until density dependent factors limit the localized carrying capacity. However, annual year class production of round goby and an abundance of favorable (i.e., rocky) habitat in the Chicago area waterways are likely to promote the continued downstream emigration of this nonindigenous species towards the Illinois and upper Mississippi Rivers (Steingraeber et al. 1996). Annual interagency sampling efforts coordinated by the U.S. Fish and Wildlife Service to determine the downstream leading edge of the round goby's distribution in the Chicago area waterways have found that the apparent downstream extent of the round goby's range has increased by at least 28 river miles (45 km) since 1998 and now extends at least 43 river miles (69 km) inland (Figure 2). The goby-inhabited reach of the IWS in metropolitan Chicago now comprises the uppermost 13 percent of this 333-mile (536-km) navigation corridor that flows diagonally across

Figure 2. The annual known downstream extent of the round goby's distribution in the Chicago area waterways.

Illinois from Lake Michigan to the Mississippi River. Thus, round goby are poised to disperse, perhaps rapidly, to other areas of the mid-continent unless timely and appropriate management actions are taken to limit continued downstream movements of this nuisance species in the Chicago area waterways.

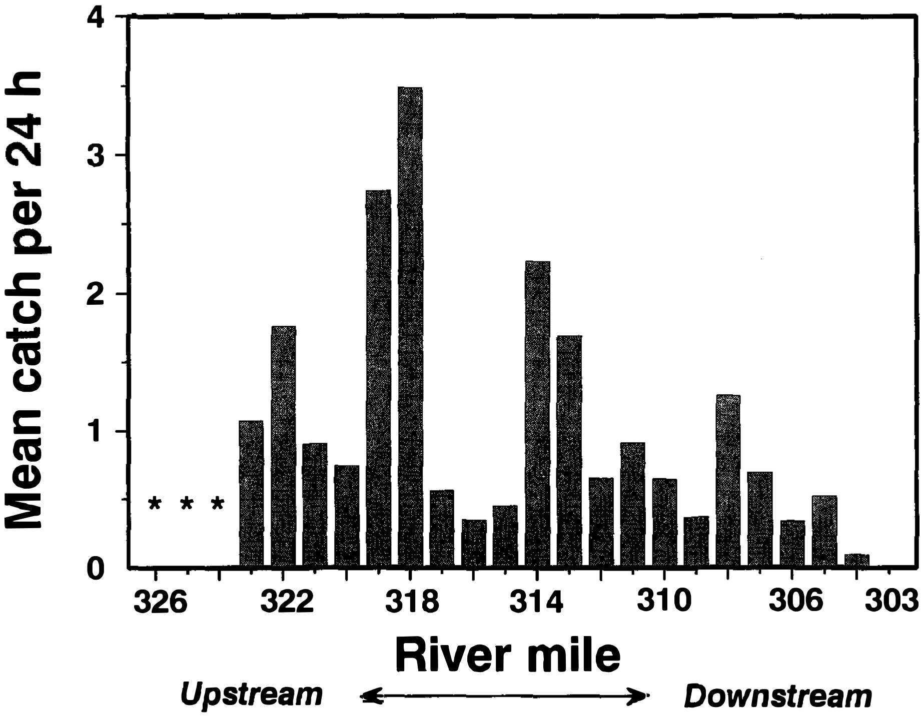
A Dispersal Barrier Demonstration Study

The development of an ANS dispersal barrier for the Chicago area waterways posed a complex array of interrelated societal concerns caused by both the acute need to stem the range expansion of round goby and the chronic need to prevent the transfer of other nonindigenous fish between the Great Lakes and the Mississippi River basin. An advisory panel of representatives from 28 different federal, state, regional, and municipal agencies, as well as industrial and environmental interests and academia, was convened to identify the most practical dispersal barriers for use in the Chicago area waterways (Moy 1997, Keppner and Theriot 1997). Factors affecting the choice of barriers included no interference with barge traffic, no change in the annual volume of water diverted by Chicago from Lake Michigan, variable flows, existing permit requirements to maintain water quality, recreational boating concerns and public perception. The consensus of this group was that both electrical fields and chemical piscicide treatments could be used to reduce interbasin movements of fish. However, the use of toxicants was recommended only on a limited basis. Therefore, an electrical barrier seemed the most practical strategy for quickly slowing the spread of round goby in the Mississippi River basin and preventing the movements of other nonindigenous fish between the Great Lakes and the Mississippi River basin.

Based on these recommendations and with Congressional appropriations from the National Invasive Species Act, the Chicago District of the U.S. Army Corps of Engineers has been examining potential methods to demonstrate and study the effectiveness of dispersal barriers in the Chicago Sanitary and Ship Canal that are designed to slow or stop the movement of aquatic nuisance species between the Great Lakes and the Mississippi River basin (U.S. Army Corps of Engineers 1999). Construction of a full water column electrical barrier designed to prevent both downstream and upstream movements of fish in the Canal (native species as well as nonindigenous species) should begin in 2000 (M.A. Kennedy personal communication: 2000). Meanwhile, other government agencies are examining the feasibility of using piscicides to help eradicate round goby in the Chicago area waterways.

Electrical barrier progress. The planned electrical barrier will consist of a micro-pulsed, direct current array (Smith-Root, Inc., Vancouver, Washington) comparable to that used to prevent upstream migrations of spawning sea lamprey (*Petromyzon marinus*) in some Great Lakes tributaries and to prevent fish from entering (or leaving) certain irrigation canals in the western U.S. Performance tests to determine the ability of prototype electrical barriers to deter round goby passage in confined laboratory and small-scale field settings have achieved success rates of about 80 percent and nearly 100 percent, respectively (J.F. Savino personal communication: 2000). The electrical barrier is scheduled to be installed in the Chicago Sanitary and Ship Canal at river mile 296.25 (river kilometer 476.67), near Romeoville, Illinois (Figure 2), and may be operational by late in 2000. The canal at this site has a nearly uniform rectangular perimeter that measures 150 feet (50 m) wide by 25 feet (7.6 m) deep (Moy 1999) and is located about 20 river miles (32 km) downstream from the reach in the Calumet Sag Channel where round goby abundance peaked during 1999 (Figure 3). By fall 1999, only one round goby had ever been captured down-

*Figure 3. Mean daily catch of round goby in baited minnow traps deployed in the Little Calumet River (river mile 319-326) and the Calumet Sag Channel (river mile 303-319), October 18-22, 1999. Note: * indicates no sampling effort at this location.*



stream of the barrier site, at river mile 290.25 (river kilometer 467.01) (Figure 2). The barrier will consist of a series of electrodes attached to the bottom of the canal and recessed into the canal walls so that barge traffic will not be impeded (Moy 1999). Supporting electrical equipment and an emergency generator will be kept in a secure shed to provide an uninterrupted power supply. The electrode array will create a graduated, pulsed, direct current electrical field to maintain a continuous barrier throughout the water column. The electrical field is not intended to stun or kill fish but to deter their continued movement (upstream or downstream) beyond the barrier. The effectiveness of the electrical barrier system in preventing the continued downstream movement of round goby will be monitored during annual U.S. Fish and Wildlife Service surveillance operations, and its impact on the movements of other fishes will be assessed by the Illinois Natural History Survey with mark-recapture studies (J. Dettmers personal communication: 2000).

Chemical barrier progress. Preliminary tests to determine the relative toxicity of several registered piscicide formulations to round goby and certain native fish species were conducted over a range of toxicant concentrations expected to illicit mortality levels of 25, 50 and 99 percent among groups of test fish within a 96-hour period. Results of this investigation indicated that although each of the piscicides (3-trifluoromethyl-4-nitrophenol, Bayluscide®, antimycin and rotenone formulations of Noxfish® and Nusyn Noxfish®) was toxic to round goby, the sensitivity of the round goby to these chemicals was too similar to that of native fishes to provide for selective removal of round goby by common application practices (V.K. Dawson personal communication: 2000). However, newly developed delayed-release formulations of Bayluscide® and antimycin may offer substantially greater selectivity for bottom-dwelling fishes like the round goby by toxifying only the lowermost stratum of water rather than the entire water column. Encouraging results from additional tests indicate that round goby are neither attracted to nor repelled by these chemicals. Since round goby do not have a gas bladder and cannot maintain a vertical position high enough in the water column to avoid the delayed-release formulations of these piscicides, they become effectively intoxicated after a relatively brief period of exposure to these chemicals (V.K. Dawson personal communication: 2000). Other laboratory and field studies are needed to determine the feasibility and efficacy of successfully applying these piscicide formulations to control round goby in lotic ecosystems like the UMRS. If eventually registered and approved for use in the Chicago area waterways or other portions of the Mississippi River basin, the delayed-release formulations of Bayluscide® and antimycin may be most effective if applied in reaches where round goby are relatively abundant, thereby helping to reduce possible density-driven range expansion while minimizing adverse impacts to native fish.

Continued vigilance. Surveillance activities for round goby comprise another integral component of the Chicago area waterways barrier demonstration study. These operations typically consist of brief but intensive sampling to determine the extent of the round goby's distribution and relative abundance within a nearly 75-mile (120.7-km) contiguous reach of waters that provide sanitary and maritime services, as well as increasing recreational opportunities, for the nations' third largest urban population. Although the multi-use character of this waterway presents a variety of logistic and technical sampling challenges, representatives from a growing number of federal, state and local government agencies, educational institutions, industries, environmental interest groups, and the media have participated with the U.S. Fish and Wildlife Service in these surveys and are essential to its continued success.

A variety of gear types have been used to sample for round goby since the study began in 1996. Our experience suggests that baited wire-mesh minnow traps offer the most efficient means of detecting this nocturnally active species, especially in the shallow rocky habitats that it seems to prefer. Survey results indicate that while the apparent leading edge of the round goby's distribution in the Chicago waterways advanced only 3 miles (4.8 km) downstream in the Calumet Sag Channel from mid-1996 to mid-1998, it progressed an additional 15 miles (24.1 km) further downstream to the Sanitary and Ship Canal confluence by mid-1999, and moved yet another 13 mile (20.9 km) downstream later that same year (Figure 2). Sampling efforts in late-1999 also revealed that round goby abundance peaked at river mile 318 (river kilometer 512) in the Calumet Sag Channel and steadily decreased further downstream (Figure 3).

Surveillance information like this has been essential in focusing public attention to the serious problems created by the round goby, as well as other invasive species now present in the Chicago area (e.g., Asian longhorn beetle [*Anoplophora glabripennis*]). Continued surveillance using standardized sampling methods and mark-recapture studies will be necessary to evaluate the long-term success of the electrical barrier and the need for other management actions to prevent interbasin movements of fish via the Chicago area waterways.

Conclusion

Faced with recurring waterborne disease epidemics that plagued Chicago during the late-19th century, city administrators of that era ingeniously engineered a solution to this public health crisis by reversing the flow of the Chicago River to dilute and flush sewage away from Lake Michigan. In so doing, this massive public works project breached a low geographic barrier that previously separated the Great Lakes and Mississippi River ecosystems. This physical connection has recently facilitated the waterborne exchange of NAS between the two largest freshwater ecosystems in America and jeopardizes the survival of certain native aquatic biota. For example, zebra mussels were spread from Lake Michigan to the Mississippi River via the Chicago area waterways and now appear to be one of the leading factors contributing to the demise of the federally listed endangered Higgins' eye pearlymussel (*Lampsilis higginsi*) in the UMRS (D.L. Strayer personal communication: 1998, A.C. Miller personal communication: 1998). Likewise, round goby have adversely affected native benthic fishes in portions of the Great Lakes and now threaten to do so in the Mississippi River basin unless their disperal can be contained.

As we enter the 21st century, there is an impending global need to explore ways to restore the biogeographic barriers that formerly separated species to protect vulnerable native species and ecosystem function. The barrier demonstration study in the Chicago Sanitary and Ship Canal is the first attempt to isolate fish in the Great Lakes from those in the Mississippi River basin. The development of practical, long-term solutions to resolve the environmental dilemmas posed by the introduction and spread of other NAS across North America requires an integrated ecosystem problem-solving process with broad-based support from all levels of government, private industry, and the general public.

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Saltcedar Invasion of Western Riparian Areas: Impacts and New Prospects for Control

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Riverine corridors and wetlands in arid regions are among the most important ecosystems for sustaining native wildlife species (Carothers 1977, Skagen et al. 1998, Sanders and Edge 1998), providing critical habitat to the majority of threatened and endangered plants and animals (Master et al. 1998) in addition to creating enormous recreational and ecosystem function values for society. At the same time, these ecosystems have been greatly altered and degraded by water diversion and regulation, agricultural practices, land development, and various forms of pollution (Allan and Flecker 1993). Still, even modified river systems provide some functional riparian ecosystem and wildlife values (Moyle 1995, Anderson 1995). However, these remaining systems are further endangered by on-going invasions of non-indigenous or "exotic" plants and animals (Dudley and Collins 1995, Wilcove and Bean 1994, Allan and Flecker 1993). Ironically, setting aside such areas to let "nature to take its course" without active management of invasive species is likely to result in further loss of declining species and a waste of efforts to protect them in the first place.

The invasion by saltcedar, tamarisk *(Tamarix* spp.), an exotic shrub or small tree from the Old World, may be one of the worst ecological disasters to befall western U.S. riparian ecosystems. Saltcedar has displaced or replaced native plant communities, degraded wildlife habitat and may have majorly contributed to the decline of many native species, particularly several now-threatened or endangered species (DeLoach and Tracy 1997, Lovich and DeGouvenain 1998), including the southwestern subspecies of willow flycatcher (*Empidonax traillii extimus*) (U.S. Fish and Wildlife Service 1995).

Conventional controls for saltcedar using mechanical removal and chemical treatments have benefitted native species in numerous locations (e.g., Barrows 1998, Inglis et al. 1996). While effective in limited and readily accessible areas, these methods are expensive and labor intensive, they often harm non-target species, and they are inadequate for treating remote and inaccessible infestations that serve as sources of new propagules. Another tool to help reduce infestations of environmental weeds is classical biological control (Huffaker 1957, Julien and Griffiths 1999, McFadyen 1998), in which specialist herbivores that feed on saltcedar in its native environment may be imported to help repress pest populations (Tracy and DeLoach 1999, DeLoach et al. 1996 in press). The apparent competitive advantage that saltcedar has over the native cottonwood/willow vegetation may be partly related to the lack of herbivores in its new range, and we anticipate that introducing the same consumer stresses that native plants must tolerate could help counter this advantage. Of the three insects approved for importation into quarantine in the U.S., the leaf beetle (Chrysomelidae: *Diorhabda elongata*) has received USDA Animal and Plant Health Inspection Service (1999) approval for release to fight saltcedar infestations after a decade of pre-release testing. *D. elongata* is currently present in cages at eight sites in six western states to evaluate survival and effectiveness under field conditions prior to general release (Gould 1999). Biological control may be attractive in these remote and widely dispersed ecosystems, because it theoretically provides a non-polluting and inexpensive method for reducing the abundance of saltcedar without harming the native plant or animal communities.

However, recently several serious concerns have arisen regarding the saltcedar biological control program (Malakoff 1999, DeLoach et al. in press). These include fears that: (1) released insects will damage non-target plants of environmental or economic concern, hence becoming problem invaders themselves; (2) saltcedar may be providing ecological or economic benefits that should not be risked; (3) saltcedar control will be wholesale and rapid, allowing inadequate time for native vegetation recovery to support wildlife in the interim; and (4) the systems where saltcedar is present have been so altered that native vegetation can no longer recover or survive. Most problematic have been the repeated delays in the biocontrol program because saltcedar has been shown to provide nesting habitat for a substantial number of southwestern willow flycatchers (Sferra et al. 1997) and under the Endangered Species Act the U.S. Fish and Wildlife Service must consider any potential loss of endangered species "habitat" as a possible "taking."

Thus, the goals of this paper are to describe briefly the nature of impacts that saltcedar has to riparian ecosystems and how human impacts relate to this invasion, to review our expectations for a biological control program to augment traditional control efforts, to gauge the potential for native vegetation re-establishment following reduction in tamarisk, and to evaluate the realistic risk that biological control agents pose to the willow flycatcher. In doing so, we wish to consider the implications of single-species management for society's broader goal to protect and enhance endangered natural ecosystems.

Saltcedar in North America

Origin and Systematics

The genus *Tamarix*, comprised of 54 species, is only native in the Old World, with one major center of speciation in central Asia and another in the eastern Mediterranean (Baum 1978). *Tamarix* and two other small Asian genera, *Myricaria* and *Reaumuria*, constitute the family Tamaricaceae. *Tamarix* is an ancient genus in Asia that is taxonomically isolated from other plant families (Baum 1978). Some 10 species of *Tamarix* were introduced into the U.S. (Baum 1967, Crins 1989) beginning in 1823. They were widely planted as ornamentals, while in the West they were also planted as windbreaks and for soil stabilization (Brotherson and Von Winkel 1986). Most species are only weakly naturalized, including several in the Southeast. However, one species *T. ramosissima* from central Asia (eastern Turkey to western China), spread explosively after the late 1920s, and by 1970 it occupied large areas of prime river floodplains and lakeshores in the western United States (Robinson 1965, Horton 1977). Another species of saltcedar, *T. parviflora*, is now invading coastal and central areas of California. Athel (*T. aphylla*), a very large, non-cold tolerant, evergreen tree, is widely but not abundantly used as ornamentals and windbreaks in the southwestern United States and northern Mexico (DiTomaso 1998). Athel is not, or is only minimally, invasive in North America, but it has become very invasive and damaging in central Australia (Griffin et al. 1989). Only *T. ramosissima* and *T. parviflora* are current targets for biological control in the United States.

The Tamaricaceae, together with the only other closely related family, the Frankeniaceae, are generally placed in the order Tamaricales (Spichiger and Savolainen 1997). *Frankenia* is a more widespread genus, native in Asia, Australia and South America. Six *Frankenia* species are native in the southwestern U.S. and Mexico, one of which, *F. johnstonii*, is endangered (Whalen 1987) but is likely to be delisted based on recent data (P. Williamson, Southwest Texas State University, personal communication: 1999).

Ecology and Impacts of Saltcedar

Native Plant Communities

The natural floodplain vegetation along many of the streams in the arid southwestern U.S. was comprised of gallery forests of cottonwoods (*Populus* spp.) and willows (*Salix* spp.); thickets of screwbean mesquite (*Prosopis pubescens*), seepwillow baccharis (*Baccharis salicifolia*), arrowweed (*Pluchea sericea*), quailbush (*Atriplex lentiformis*), and seepweed (*Suaeda occidentalis*); and low woodlands of mesquite (*Prosopis glandulosa* and *P. velutina*) (Grinnell 1914). These areas were in dynamic equilibrium, in which semi-predictable natural disturbances maintained the vegetation in an early successional state (Fisher 1990). The native plants and animals are adapted to those conditions and, in fact, depend upon flood disturbance to maintain diverse structure, age classes and community composition, as well as to facilitate seed deposition and germination (Poff et al. 1997).

By the 1950s, saltcedar occupied most western riparian areas along major streams from the central Great Plains to the Pacific and from northern Mexico to southern Montana. Major infestations have replaced up to 50 percent, and often nearly 100 percent, of the native vegetation along large areas of many of the major streams within its distribution (Horton and Campbell 1974). Accounts have decribed the demise of the cottonwood forests along the lower Colorado River—from the original 5,000 to 10,000 acres to the 500 acres that remained by 1972 (Ohmart et al. 1977, Turner 1974). In fact, saltcedar occupied 900,000 acres by the mid-1960s (Robinson 1965). Areal coverage estimates vary widely, but today saltcedar today probably occupies more than 1.5 million acres (Brotherson and Field 1987), including 29,000 acres on 33 western national wildlife refuges (Stenquist 1996).

Anthropogenic habitat alteration certainly played a role in promoting this expansion (Everitt 1980, Anderson 1995, Brotherson and Field 1987), but the plant also continues to spread in relatively undisturbed tributaries, smaller streams and around desert springs throughout the West (Deuser 1997, Lovich and DeGouvenain 1998, Barrows 1998, Tracy and DeLoach 1999). Ohmart et al. (1977) questioned whether the native plants could have withstood the saltcedar invasion even without water regulation. Turner (1974) demonstrated that saltcedar replaced the native species on the middle Gila River without dam effects.

Wildlife Impacts

Wildlife habitat has been seriously degraded in many saltcedar infested areas, both because of the loss of habitat complexity and quality. The abundance of all birds found in saltcedar on the lower Colorado was only 39 percent of the levels in native vegetation during the winter and 68 percent the rest of the year; the number of bird species found in saltcedar was less than half that in native vegetation during the winter (Anderson et al. 1977). Saltcedar was the most important negatively correlated variable identified with bird populations (Anderson and Ohmart 1984). Frugivores, granivores and cavity dwellers (woodpeckers, bluebirds and others) are absent, and insectivores are reduced in saltcedar stands (Cohan et al. 1979). Seven bird species, including Arizona Bell's vireo (*Vireo bellii arizonae*), Gila woodpecker (*Centurus uropygialis*), gilded northern flicker (*Colaptes chysoides*), vermilion flycatcher (*Pyrocephalus rubinus*), summer tanager (*Piranga rubra*), western yellow-billed cuckoo (*Coccyzus americanus*), and elf owl (*Micrathene whitneyi*), are in serious decline along the lower Colorado River and the Sonoran yellow warbler (*Dendroica petechia*) and southwestern willow flycatcher have been extirpated from the area (Hunter 1984). Only 2 percent of the yellow-billed cuckoos were found in saltcedar, 0 percent of Bell's vireos, 2 percent of summer tanagers, and 8 percent of the yellow-breasted chats (*Icteria virens*) (Hunter et al. 1985). At Camp Cady in southern California, the bird population was only 49 percent as great in saltcedar as in cottonwood/willow/mesquite (Schroeder 1993). Bird preference for saltcedar was much lower than for native vegetation along the middle Rio Grande, Texas (Engel-Wilson and Ohmart 1978) and somewhat lower on the middle Pecos River (Hildebrandt and Ohmart 1982). Few birds were attracted to dense, monocultural stands of saltcedar, but the inclusion of some native trees, especially cottonwoods, willows or mesquites, greatly enhanced the attractiveness to birds (Engel-Wilson and Ohmart 1978, Hildebrandt and Ohmart 1982). The cottonwood/willow vegetation type is critical to a vast number of avian species, not only those nesting in it but also larger numbers under tight resource demand which depend upon associated food resources during migrations through these areas (Skagen et al. 1998).

Some species do nest regularly in saltcedar-dominated patches, such as the white-winged dove (*Zenaida asiatica*), Mississippi kite (*Ictinia mississippiensis*), black-chinned hummingbirds (*Archilochus alexandri*) and various passerine birds (Glinske and Ohmart 1983, Rosenberg et al. 1991, Brown 1992). Nonetheless, even in its natural range, *Tamarix* is apparently not a particularly valuable vegetation type for avian wildlife (Brooke 1982, Lovich and DeGouvenain 1998).

One reason for the poor quality of saltcedar as bird habitat in North America is its relatively depauperate associated insect assemblage. Few native insects feed directly upon it (Liesner 1971), and the most common herbivore across its American range is an accidentally introduced leafhopper (*Opsius stactogalus*) (Liesner 1971, Stevens 1985). The one exception is the Apache cicada

(*Diceroprocta apache*) whose nymphs feed on the roots of cottonwoods, willows and also saltcedar (Glinski and Ohmart 1984). Insect biodiversity is also typically much higher on native plants like coyote willow than on saltcedar, although in one case insect abundance (mostly leafhoppers and Apache cicada) was greater on saltcedar. Numerous insects, including European honeybees, use saltcedar nectar and pollen and act as pollinators but do not otherwise feed on the plant.

Populations of furbearers and small rodents also are lower in saltcedar than in other vegetation types on the Rio Grande of western Texas (Engel-Wilson and Ohmart 1978) and on the Pecos of New Mexico (Hildebrandt and Ohmart 1982). On the Rio Grande of western Texas, saltcedar wetlands ranked fourth and saltcedar sixth in the number of small rodents caught, among seven vegetative types sampled (Engel-Wilson and Ohmart 1978). In Big Bend National Park, Ord's kangaroo rat and beavers have been nearly eliminated because of the saltcedar invasion (Boeer and Schmidly 1977). On the middle Rio Grande, saltcedar types ranked 9th, 15th and 16th among 25 community-structural types in numbers of small mammals trapped (Hink and Ohmart 1984).

Along the Gila River near Florence, Arizona Jakle and Gatz (1985) trapped three to five times as many lizards, snakes and frogs in native vegetation types than in saltcedar. Saltcedar dried up springs and small streams thus forcing wildlife to flee or die in Death Valley (Rowlands 1989). Many desert fish species may be adversely affected by the narrower, deeper and more homogenous stream habitats and by the reduction in numbers and types of food insects caused by the saltcedar invasion (Graf 1978, Blackburn et al. 1982, Schoenherr 1988, Bestgen and Platainia 1991). At Ash Meadows National Wildlife Refuge, Nevada, T. Kennedy (Unpublished data) found that the endangered Ash Meadows speckled dace (*Rhinichthys osculus nevadensis*) benefitted from experimental saltcedar removal, and is testing the hypothesis that reduced population size is caused by the saltcedar litter being unsuitable for production of the aquatic insects the dace needs.

From a list provided by the U.S. Fish and Wildlife Service's (FWS) Region 2 (Albuquerque), DeLoach and Tracy (1997) reviewed some 51 threatened or endangered (T&E) species, or proposed T&E species, that occupy western riparian areas infested by saltcedar. These included 2 mammals, 6 birds, 2 reptiles, 2 amphibians, 34 fish, 1 arthropod, and 4 plants. Of the 51 T&E species, 40 were concluded to be negatively affected by saltcedar invasion. Several of these T&E species may utilize saltcedar to some extent, but not to a degree that would make it appear important to them or as valuable as the native vegetation it has replaced (Anonymous 1995). As saltcedar dominance increases and the native plants decrease, populations of these wildlife species are likely to decrease for lack of resources, including the type and quantities of insects required by insectivores. Of additional critical concern is the high susceptibility of saltcedar is to wildfire, particularly as its densities increase, which poses increasingly serious threats to all the remaining wildlife that occupies infested habitats. For example, a recent fire in the Salton Sea National Wildlife Refuge was fueled partly by saltcedar, and diminished the cattail-bullrush habitat for the endangered Yuma clapper rail (*Rallus longirostris yumanensis*).

In other regions threats to T&E species are similar, such as in the central Great Plains where saltcedar has overgrown the gravel bars along streams, preempting this essential nesting habitat of the interior least tern *(Sterna antillarum*), and the bald eagle (*Haliaeetus leucocephalus*) (delisted July 1999) has been harmed by the great reduction in the large cottonwoods that are one of its preferred nest trees (Anonymous 1995, DeLoach and Tracy 1997). Other species affected include peninsular bighorn sheep (*Ovis canadensis cremnobates*), Concho water snake (*Nerodia paucimaculata*) which is found only in the Concho and Colorado rivers of western Texas, western pond turtle (*Clemmys marmorata*) and the endangered desert slender salamander (*Batrachoseps aridus*) in the Mojave River and elsewhere (Lovich and DeGouvenain 1998, Lovich et al. 1994). The habitat of 34 regionally listed fish species is seriously degraded by reduced water levels, modified channel morphology, silted backwaters, altered water temperature, and probably by reduced and modified food resources. Examples of saltcedar degradation of endangered fish habitats include the loss of shallow sandbar habitat for the Rio Grande silvery minnow (*Hypognathus amarus*), loss of critical low velocity nursery habitat for the Colorado squawfish (*Pytocheilus lucius*), and reduction in spring water levels for the desert pupfish (*Cyprinodon macularis*). On the other hand, the juveniles of one endangered fish, the humpback chub (*Gila cypha*), are using saltcedar debris for cover in the Grand Canyon, however this reflects the low abundance of native vegetation on this modified river (Converse et al. 1998). The proposed threatened Pecos sunflower (*Helianthus paradoxus*) is threatened by saltcedar encroachment into its habitat (B. Radke personal communication: 1998, Tracy and DeLoach 1999).

Other Problems

Stream channel modification. Dense thickets of saltcedar along streams cause increased sedimentation, bank aggradation, narrowing and deepening of channels, filling in of backwaters, modifications or elimination of riffle structure, overgrowth of sand and gravel bars, and changes in turbidity and temperature of the water. Channels sometimes are completely blocked with debris and overbank flooding is more severe (Busby and Schuster 1971, Burkham 1972, Graf 1978, 1999).

Human resources. Saltcedar substantially reduces recreational usage of parks, national wildlife refuges and other riparian areas for camping, hunting and fishing, boating, birdwatching and wildlife photography (Kunzmann et al. 1989, DeLoach 1991). This occurs not only because saltcedar causes declines in many desirable species but also because saltcedar creates nearly impenetrable stands that block access to other habitats, it drips brine in humid mornings, and it accumulates dust. It reduces the livestock stocking capacity by displacing forage grasses, by using ground water or irrigation water that otherwise could be available to grow forage or crop plants, by increasing soil salinity, and by increasing the incidence of fires. Also, it has a low palatability to livestock and is inferior to native cottonwood/willow for resting or loafing areas during the summer.

How Does Saltcedar Invade Desert Riparian Areas?

A variety of physiological and ecological traits allow saltcedar to establish successfully and, under certain conditions, to outcompete native riparian vegetation. It is capable of very rapid growth and can achieve reproductive maturity in a single year. The insect- and wind-pollinated flowers and seed-set occur over a long period from late spring through the fall, a single plant producing more than half million extremely small seeds, which fortunately are only viable for several weeks (Horton et al. 1960, Warren and Turner 1975). This allows saltcedar to germinate when conditions are unpredictably favorable, whereas the native plants it replaces are much more constrained in terms of when viable seeds are present (Stromberg 1998). The seeds are widely distributed by wind and water, even into remote canyons and inaccessible moist springs, and within a season dense thickets often arise on bare mud or sand surfaces.

Once dominance is attained, saltcedar appears to modify ecosystem processes and effectively preclude the re-establishment of native species through natural processes (Smith and Devitt 1996, Cleverly et al. 1997). Both biotic and abiotic environmental factors are important in facilitating this establishment and dominance of saltcedar in western streams, and its presence alters ecosystem attributes in ways that further contribute to its own success.

Water relations. Saltcedars are facultative phreatophytes, meaning they require direct contact with free groundwater for part of the year but are capable of utilizing soil water during drier periods (Busch et al. 1992). Saltcedar uses great amounts of groundwater in arid regions where availability is critical for natural ecosystems, agriculture, municipalities and industry (Horton 1976). The usage of water by saltcedar has been evaluated by various methods, and best estimates vary from around 5.7 acre feet of water lost through evapotranspiration per year in the lowest and hottest areas along the lower Colorado to 3.2 feet at higher elevations along the middle Rio Grande in New Mexico (Gatewood et al. 1950, U.S. Bureau of Reclamation 1973, van Hylckama 1980, Gay and

Fritschen 1979, Gay 1985, Busch et al. 1992), including measurements in river channels before and after clearing saltcedar on the Gila (Culler et al. 1970) and Pecos Rivers (Weeks et al. 1987).

Saltcedar water use is roughly equivalent to other riparian plants on a leaf area basis; however, because leaf area is greater than native willows, groundwater use rates are higher on an areal basis than the natives (Sala et al. 1996). In one experiment in lysimeter tanks, saltcedar used 51 to 72 percent more water at 40 to 60 inches depth to water table than did seepwillow (*Baccharis salicifolia*) (Gatewood et al. 1950). Willows and cottonwoods also are obligate, rather than facultative, phreatophytes meaning they can only lose contact with the water table temporarily and cannot use soilwater during such periods. Saltcedar, being deeper rooted, can grow farther back from the river and can extract water from a deeper level than can cottonwood/willow stands, and thus can occupy a larger area and use more water across the floodplain than would be possible by the native phreatophytes. Under natural conditions, less dense communities of mesquites, quailbush or other mesic plants, which use less water than saltcedar (Sala et al. 1996, Cleverly et al. 1997), would occupy these areas farther from the river.

Certain traits, including higher leaf area per unit sapwood area, tighter stomatal control, and quick recovery after drought, give saltcedar a competitive advantage over other riparian plants in naturally arid environments as well as in systems where water tables or water availability are reduced by dams or groundwater pumping. Areas dominated by saltcedar become progressively more xeric over time as water tables are lowered (Brotherson and Field 1987), which results in drying of springs in places as distant as Big Bend National Park, Texas and the Coachella Valley, California (Barrows 1998). As a consequence, native moisture-dependant plants are displaced and surface desiccation inhibits germination of new plants, yet drought-tolerant saltcedar maintains or increases its dominance. While seedlings of both saltcedar and the native species require sustained mesic conditions in surface soils for establishment (Everitt 1980, D'Antonio and Dudley 1997) and under such conditions young cottonwoods withstand competition from saltcedar seedlings (Sher et al. in press), drought tolerance may eventually override this short-term advantage in naturally variable environments.

Salinity. As its common name implies, saltcedar is a facultative halophyte able to utilize saline groundwater and excrete the excess salts through leaf glands (Hem 1967). The brine then drips to the soil surface, or falls with the deciduous leaves in autumn to create a saline soil/litter layer. This prevents some plants from germinating or growing among saltcedars stands (Thomson et al. 1969, Shafroth et al. 1995), although other native plants found in intermittent desert rivers (e.g., *Pluchea*, *Prosopis* spp., *Hymenoclea*, *Baccharis*, *Isocoma*) can germinate at higher salt levels (D'Antonio and Dudley 1997). Cottonwoods and willows can tolerate salinity levels of only 1,500 to 2,000 parts per million (ppm), but saltcedar can grow at 18,000 to 36,000 ppm (Jackson et al. 1990). Saltcedar does not favor saline conditions, it only tolerates them better than do most other plants and, therefore, is capable of self-replacement in these salinated environments.

Risk of fire. Wildfires are rare in native riparian plant communities. Saltcedar thickets, however, are highly flammable and burn more frequently and more destructively than the native vegetation, especially as a result of the large quantity of dry leaf litter that accumulates under the stands (Busch and Smith 1992). Tamarisk-fueled fires have been observed throughout the Southwest. These fires often kill all cottonwoods, damage other native vegetation, demolish wildlife breeding areas (Paxton et al. 1996), and destroy campsites, fences, etc. (Ohmart et al. 1988, Busch and Smith 1992, J. Belnap personal communication 1997). However, saltcedar readily regrows from burned root stumps the next year, and thus rapidly dominates an area after a fire (Minckley and Brown 1982, Ohmart et al. 1988, Smith et al. 1998).

Human interference with hydrology and disturbance regimes. Many of the changes that human activity has brought on the natural landscape have played a role in fostering saltcedar invasion (Horton and Campbell 1974, Horton 1976, Everitt 1980, Stromberg 1998). The construction of large dams has changed the natural hydrologic cycle from a pattern of a high, brief, spring flood following the annual spring snow melt or heavy rainstorms, to a pattern of low floods that extend into the summer or fall, or of no floods. Cottonwoods have evolved with this natural cycle and produce seeds that germinate and establish on the exposed mud banks as the natural spring floods recede. By the time the low, anthropogenic summer floods recede, cottonwoods have ceased producing seeds though saltcedar can establish whenever the floods recede (Everitt 1980, Stromberg 1997). Also, saltcedar establishes on the mudbanks, preempting these potential cottonwood nursery sites and preventing cottonwood establishment even if the flood cycle is natural in following years. Likewise, major infestations of saltcedar established after high waters declined in reservoirs or lakes (Turner 1974).

Flood disturbance tends to cause greater mortality to juvenile saltcedar than to native seedlings of several species, and frequent disturbance can keep invader densities acceptably low (D'Antonio et al. 1999, Stromberg 1997). However, once established saltcedar is quite resistant to flood mortality and can experience extreme degrees of above-ground damage while still resprouting from the deep taproot. Therefore, reduction in flood frequency and/or intensity, or its near elimination below dams, has in many situations allowed the establishment, expansion and eventual dominance of saltcedar (Everitt 1998). River regulation in regions with naturally saline soils also has resulted in increased salinity, which favors saltcedar at the expense of less tolerant cottonwood and willows (Anderson 1995, Shafroth et al. 1995). The natural spring floods leach out these salts, but with the present reduction or absence of flooding the salts continue to accumulate. Saltcedar then accelerates this salinization process by its own excretion of excess salts.

Long reaches of several western rivers have been dredged and channelized during the past 50 years to conserve water (Pacific Southwest Inter-agency Committee 1966, Carothers 1977). Channelization lowered water tables below the level where shallow-rooted, riparian obligate cottonwoods, willows, seepwillow baccharis, and other plants could reach the water, causing significant mortality of these species. Maximum depth to water table that will allow the growth of healthy cottonwoods and willows is six feet, with a two-foot annual fluctuation (Bureau of Reclamation 1995). Diversion of water in streams and pumping of groundwater, for both agricultural and municipal use, also has critically reduced water tables in many western areas. The large usage of water by saltcedar itself accelerates the lowering of water tables and to a deeper level than is normal (Busch et al. 1992, Smith and Devitt 1996). Stream incision and downcutting also lower water tables and are of widespread occurrence throughout the West, caused by floods but often exacerbated by livestock overgrazing (Chambers et al. 1998, Stromberg 1998). Another widespread water conservation practice during the mid-1900s involved total removal of phreatophytic vegetation (exotic and native) in Arizona and New Mexico (Pacific Southwest Inter-agency Committee 1966, Carothers 1977). Every mile of riparian habitat in Arizona was cleared or scheduled for clearing, and even the cottonwoods in the Verde Valley, Arizona were destroyed for flood control (Fox 1977). While these programs were halted by court injunctions in 1970 (Gilluly 1971), the clearing gave saltcedar a further competitive advantage, and it then rapidly regrew and gained dominance in many of these areas.

Invasions without human disturbance. Saltcedar invasion has not been restricted to areas greatly altered by past human activities. Examples exist along the Brazos River in Texas (Busby and Schuster 1971), the middle Gila River (Turner 1974), the Colorado River in Canyonlands National Park, Utah (Thomas et al. 1989), the Virgin River, Nevada (Kasprzyk and Bryant 1989), tributary streams at Lake Mead NRA (Inglis et al. 1997, Deuser 1997), the Mojave River at Afton Canyon (Egan 1997) and the San Miguel River in Colorado (B. Richter personal communication: 1998). It has established throughout the West at remote springs, streams and washes with minor human influence and distant from major regulated rivers, and sometimes thousands of feet above grazed or cultivated areas (Lovich and DeGouvenain 1998). Along Coyote Creek in Anza-Borrego State Park, California, saltcedar invaded a watershed in a designated wilderness area; thus, successful invasion occurred with minimal human disruption (D'Antonio and Dudley 1997). Saltcedar apparently "displaces" rather than "replaces" native vegetation by taking advantage of natural openings, and the weedy traits described earlier (small, easily dispersed seeds, long period of flowering and seed-set, rapid time to reproduction, tolerance of diverse metabolic stresses, etc.) allow it to be an effective colonizer and competitor. The often stated explanation that saltcedar only opportunistically occupies areas already damaged by high soil salinity, low water tables, etc. is incomplete.

Lack of natural controls. Although established willows appear to inhibit growth of saltcedar (J. Belnap personal communication: 1997), it is clear that competition from other plants is not a dependable mechanism for resisting saltcedar expansion. Because few native insects feed more than occasionally or sporadically on saltcedar and cause it little damage, the lack of herbivore damage further enhances the ability of this weed to compete with other vegetation (DeLoach et al. in press). The insects seen at saltcedar flowers feed on nectar and pollen and cause saltcedar little or no damage, while their herbivorous immature stages are often produced on nearby native vegetation and may provide an additional saltcedar advantage by damaging the native plants (and even by providing the adult insects with an additional food supply!). Except for the Apache cicada in the Grand Canyon (Stevens 1985), the only existing insect that appears to have significant control potential is the introduced leafhopper, *Opsius stactogalus*, and this only in confined spaces (Tracy and DeLoach 1998). In fact, this insect may provide benefits to native wildlife as a food source for several riparian birds (Yard 1996), including the willow flycatcher (C. Drost personal communication *in* Tracy and DeLoach 1998). Four other Eurasian, saltcedar-specific arthropods also have been accidentally introduced but have caused little or no damage.

Saltcedar Biological Control

The Biological Control Program

The lack of effective natural enemies of saltcedar in invaded ecosystems of North America, unlike in Eurasia where the insects and plant pathogens attack saltcedar, is almost certainly a major cause of its domination of our riparian plant communities. The biological control program we are undertaking seeks to introduce those highly host-specific and most effective natural enemy species into the United States. Saltcedar sometimes dominates areas in its native range in the Old World, but seldom to the extent seen in the western U.S. In the Old World, its populations are considerably suppressed by herbivory from many insect species (Kovalev 1995, Gerling and Kugler 1973, Habib and Hassan 1982, Zocchi 1971, DeLoach et al. in press), even though these herbivores often are attacked by their own parasitoids and predators. We may expect better control in the U.S. because these parasitoids and predators will not be introduced. Successful cases of biological control of environmental weeds (over a dozen in the continental U.S., another 10 in Hawaii, and many others in more than 50 countries) demonstrate that the introduction of one or a few insects or plant pathogens can reduce an aggressive, dominant weed to a position of minor importance in the plant community (Huffaker and Kennett 1959, McFadyen 1998). Thus, biocontrol is intended to make saltcedar act like a "good citizen" in the riparian community. Indeed, these efforts may even increase its beneficial value for wildlife by enhancing the insect assemblage associated with this otherwise relatively sterile host plant. Eradication is extremely unlikely, even if desirable to many resource managers and conservationists, except in cases where traditional methods are used to augment biological control.

Testing was initiated on some 20 species of insects in France, Israel, Turkmenistan, Kazakhstan and China. Seven of these have been received into quarantine in Temple, Texas for further testing, and testing has been completed on three species: a leafbeetle (*Diorhabda elongata*) from central Asia and China; a mealybug (*Trabutina mannipara*) from Israel; and a foliage-feeding weevil (*Coniatus tamarisci*) from France (DeLoach et al. 1996). Extensive host-range testing in Temple, Texas of adult feeding and survival, ovipositional host-plant selection, and larval feeding, survival and development of *D. elongata* and *C. tamarisci*, and similar no-choice testing of nymphs and adults of *T. mannipara*, have demonstrated that these three candidate control insects are highly restricted in host range to species of *Tamarix*. The test results for *D. elongata* and *T. mannipara* have already been critically reviewed by the APHIS multi-agency Technical Advisory Group for the Introduction of Biological Control Agents of Weeds, and by Fish and Wildlife Service (FWS). These agencies have approved the experimental release of *D. elongata* in six states (Texas, Colorado, Utah, Wyoming, Nevada and California), and trials in large cages are currently underway to establish that this insect will reproduce and survive under field conditions.

Critiques of Biological Control

Recent critiques of the use of natural enemy introduction to control pest plants primarily question the degree of specificity of host ranges, and the potential for specialist herbivores to "switch" to feeding on non-target plants of economic or environmental concern (Simberloff and Stiling 1996, Johnson and Stiling 1998, Louda et al. 1998, Civeyrel and Simberloff 1996). This opinion also was expressed in regards to the saltcedar biocontrol program by the Director of

FWS Region 2, which includes Arizona and New Mexico (N. Kaufman personal communication: 1999).

An additional concern has arisen in the biological review of the status of the southwestern willow flycatcher that seems to be unique to the saltcedar control program. Because some populations of this listed bird nest in substantial numbers in saltcedar, and possibly even prefer saltcedar for nest sites in some situations (Sferra et al. 1997, McKernan and Braden 1999), the FWS Willow Flycatcher Recovery Team is worried that biocontrol will work too well! In other words, that saltcedar reduction will occur too rapidly for native vegetation to recover and compensate for the reduction in saltcedar forests, particularly in locations where site potential may be poor for native vegetation recovery (Anderson 1995). This concern is serious, but we feel that it lacks consideration of several important factors that render it unnecessary.

Non-target Impacts of Biological Control Agents

While the popular notion of biocontrol gone awry concerns cases like the cane toad or mongoose introductions, which were wildly misguided actions with little bearing on the current controversy, legitimate concerns over feeding on non-target plants have spawned much re-evaluation of this technology (Louda et al. 1998, McEvoy 1996). The primary criticisms are that scientific analyses of non-target impacts have not been sufficient prior to introductions taking place, that monitoring has been inadequate to evaluate possible unintended impacts, and that the low rate of success may not justify the risks inherent in application of biological methods of weed control.

It is widely understood by those actively involved in the field that these criticisms are excessive, often incorrect, and lack perspective. The success rate of classical weed biocontrol is reasonably high, with estimate that nearly 30 percent of more than 725 releases worldwide achieved a level of "success" in controlling target species with relatively low project costs, long-term sustainability of control, and few unintended impacts (Julien and Griffiths 1999, McFadyen 1998). This is an enviable benefit/cost ratio, despite the unfortunate difficulties of field assessment. Biological control of weeds actually has an excellent history in regard to non-target effects, with apparently only eight examples of damage to non-target plans recorded worldwide (Julien and Griffith 1999). In almost all these cases such incidental feeding was anticipated by host testing prior to release. Thus, the science did not fail, but the decision was taken to release those agents despite the test results (e.g., the well-known case of *Rhinocyllus conicus* on thistles) (Louda et al. 1998). In today's more environmentally-aware society this weevil would be rejected in an early stage of assessment, but 30 years ago attitudes were different and all thistles, introduced as well as native ones, were regarded as weeds so it was decided to release

Rhinocyllus. In fact, in a detailed study, non-target impacts of *Rhinocyllus* to native thistles were concluded to have minor long-term ecological importance (J. Herr unpublished data), validating Miller and Aplet's (1993) conclusion concerning the risks of biological control that "a little knowledge is a dangerous thing."

Current testing methods are rigorous, with several levels of regulatory evaluation before an agent is approved for general release by the multi-agency Technical Advisory Group. Saltcedar provides a good example of the stringent standards increasingly involved in testing and approving releases, with almost 10 years of trials conducted in the countries of origin prior to any insects being brought into quarantine in the U.S., as described above and with more details by Tracy and DeLoach (1998). Here, further host range tests were conducted with 53 test plants from 22 families and with many agricultural plants in the regions where control is desired (Animal and Plant Health Inspection Service 1999), at this stage as much to assuage concerns of property owners as to increase confidence in agent specificity (Carruthers, unpublished data). And because initial testing indicated minor feeding but poor development on the related native halophyte (*Frankenia johnstonii*) we also are doing additional laboratory and field cage testing with all four species of *Frankenia* that are found in the U.S., even though such incidental feeding was originally documented and APHIS and FWS approval was given after balancing the expectations of minor non-target impact against the benefits of the program. No method of weed control is 100 percent risk-free; we have to assess the risks and decide accordingly, and we now have a high degree of confidence in the safety of this program, particularly in light of the risks of continuing degradation of riparian areas inherent in a "no action" response.

Many biocontrol workers even welcome the increased attention and skepticism brought by recent critiques, which serve to balance excessively rosy expectations of biocontrol as the savior of Nature, as well as to inject greater scientific rigor into the introduction process (McEvoy 1996). Wildlife protection agencies, and the FWS particularly, generally and strongly support the use of biological control as part of an integrated pest or weed management approach to control non-indigenous or invasive species that threaten protected wildlife habitat (U.S. Fish and Wildlife Service 1997).

Biological Control and Southwestern Willow Flycatcher Habitat

The fact that the southwestern willow flycatcher is nesting extensively in saltcedar in mid-elevational areas of Arizona, areas where willows have been mostly replaced by saltcedar, seriously complicates the saltcedar control program. In other states (California, Nevada, Colorado, New Mexico, Utah) it nests entirely or almost entirely in native vegetation, but special considerations and precautions must be taken to minimize risks that saltcedar removal might further reduce southwestern willow flycatcher populations where it is using saltcedar (U.S. Fish and Wildlife Service 1995). Thus, by agreement with FWS all field research sites have been eliminated that are within 200 miles of such habitats, and none is in a watershed that drains into southwestern willow flycatcher nesting areas. Releases would be made into secure field cages during the first year (in progress). After overwintering, the cages may be removed during the second and third years. Intensive monitoring will be done during this period, and for some years thereafter, of (1) the effects of the control insects on saltcedar and of any possible attack on non-target plants, (2) rate of insect dispersal in habitats with varying levels of saltcedar infestation, (3) native vegetation recovery following saltcedar control, and (4) wildlife recovery after vegetation recovery (DeLoach and Gould 1998). Nonetheless, the Recovery Team appears to be increasingly skeptical about continuation of the biological control program at all. Are these concerns reasonable?

Anticipated rate and extent of saltcedar control. Our expectation is that, if tamarisk leaf beetles successfully feed and reproduce, dispersal will not be rapid and that saltcedar control will be gradual over many years at a given site, allowing time for the concurrent recovery of willows and other native plants without loss of habitat for the southwestern willow flycatcher. The rate of spread cannot be accurately predicted before any field releases have occurred, but other similar-sized chrysomelid beetles such as *Aphthona* spp. (biocontrol agents for leafy spurge) and *Galerucella* spp. (agents for purple loosestrife) spread relatively slowly, on the order of several tens of meters per year (Animal and Plant Health Inspection Service 1999). Given the present 200-mile distances of the proposed release sites from southwestern willow flycatcher nesting areas, it is unlikely that beetles would even reach nesting areas for at least 10 to 20 years, and they may never reach there since the approved release sites are separated from nesting areas by ecological barriers as well.

Based on impacts to host plants in quarantine, and on observations from regions of origin, we (optimistically) predict an ultimate 75 to 85 percent level of control after 10 or more years following establishment of *Diorhabda* in a particular area (Animal and Plant Health Inspection Service 1999). This slow rate of impact reflects several factors that may slow down the process. First, most mature tree species are able to tolerate complete defoliation for one or more years without being killed, and have reserves to recover each new growth season. Saltcedar is particularly resilient to and tolerant of catastrophic damage (from floods, fires, or pruning), so we anticipate that numerous seasons of severe defoliation would be required to exert control to mature plants. In addition, trial studies with *Diorhabda* in North American environments indicate that it completes two generations per year and then enters diapause in late summer, at a time when the plant is still actively producing leaf tissue (Gould 1999). Thus, saltcedar is able to recover substantially within the same season. Biological control is usually applied to herbaceous plants, and success is often achieved rapidly, over the course of a few years in an infested site, and woody plants are less frequently targetted for such treatment (Julien and Griffiths 1999). Natural enemy introduction against *Sesbania punicea*, an aggressive invader in southern Africa, has been reasonably successful but requires many years and multiple insect species for substantial control to be achieved (Hoffman and Moran 1998), and that project provides a better model for comparison with the saltcedar project than most of the herbaceous plant biocontrol projects conducted in this country. Finally, observations in Asia of relatively healthy saltcedar stands in close proximity to stands heavily defoliated by *Diorhabda* suggest that herbivores are patchy in distribution, and we expect to see the same behavior here. Our expectations are that the most significant damage will be to seedlings and young plants which have not developed the stored reserves to recover from defoliation (and which are never used by willow flycatchers), which means that reproduction and new establishment will be inhibited while mature trees likely will remain and decline slowly until mortality from disturbance and/or senescence.

The slow rates of dispersal of the biocontrol agent and impact to target plants means that, if site potentials are suitable for native vegetation to thrive, then resource managers should have more than sufficient time to make plans for facilitating ecosystem recovery, and desired plants will have ample time for establishment as saltcedar is gradually declining. Some plants will likely remain, but with their aggressiveness and competitive advantage reduced. In addition, ecosystem changes resulting from saltcedar infestations (reduced water tables, soil salinity, wildfires, etc.) should be concommitently reversed, to the benefit of willow flycatchers and all others wildlife associated with riparian areas.

Potential for native vegetation recovery. The most critical concern for the Flycatcher Recovery Team, and for the Saltcedar Biocontrol Program participants as well, is whether native vegetation will return after control is achieved, or in sufficient amount and quality to provide satisfactory breeding habitat, especially in areas where water tables are too deep or soil salinity is too high. There is ample evidence that recovery can occur following traditional saltcedar control work in some smaller rivers and desert springs, with attendant improvement for associated wildlife (Neill 1985, Inglis et al. 1996, Egan 1997, Deuser 1997, Barrows 1998, T. Kennedy personal communication: 1999). These are sites that have not been otherwise too heavily altered by human intervention other than by saltcedar invasion, and return of surface water, reduction in salinity levels, etc. have been seen. Such sites represent a large proportion of western riparian areas and these often remote ecosystems continue to be invaded by saltcedar.

The problem areas are along major river systems that have experienced greater alteration. It is thought by some that, while saltcedar may not be a highly desirable plant, it is not so much an aggressive invader but in many areas, simply an opportunist that is better adapted to colonize areas that have become too dry and/or saline for survival of native vegetation (Stromberg 1998, Anderson 1995, Everitt 1998). Hence, the native species have not been displaced, and are unlikely to recover if saltcedar is reduced in abundance (R.D. Ohmart *in* Malakoff 1999). Proponents of this view often use examples from the lower Colorado River valley but ignore contrary examples along other rivers and many tributaries and small streams. We are in complete agreement that one of the most important actions that should be implemented in southwestern river management is to return at least some elements of a natural hydrological regime that may facilitate re-establishment of cottonwoods and other natural disturbance-associated riparian taxa (Stromberg 1998, Graf 1999).

However, the evidence that these species could not survive, with or without active revegetation efforts, is not robust and needs more critical evaluation. The lower Colorado is one of the most highly degraded major rivers in the Southwest, and saltcedar now dominates large areas along it. Busch and Smith (1995) experimentally cleared saltcedar thickets from around remnant willow clumps, leaving control clumps uncleared. The following growing season, the willows produced 80 percent more biomass where saltcedar was removed than at the control plots. This demonstrated the potential for restoration even here, where recovery is often deemed impossible. This test also demonstrated that direct competition by saltcedar was a major factor in the suppression of willows here, since depth to water table and soil salinity did not change during the experiment nor between control and treatment plots.

Manual revegetation. Several large-scale revegetation projects were carried out along the lower Colorado during the late 1970s and early 1980s, mostly using cottonwood poles but also using willows, mesquites and other plants (Pinkney 1992). Techniques were not well-established, and mortality was high throughout (except for mesquite) due to planting methods and poor site selection (water table depth, soil salinity) and failure to protect against livestock and wildlife browsing, weeds and insect damage. Later, Briggs (1992) surveyed 27 revegetated sites in Arizona and found that 13 of the revegetation attempts were successful and that at 10 sites natural revegetation was good. More recently, the USDA Natural Resource Conservation Service (NRCS) Plant Materials Center at Los Lunas, New Mexico developed manual revegetation methods that produce 95 percent survival and continued growth of cottonwoods, willows and other native plants in riparian areas (Swenson and Mullins 1985, G. Fenchel personal communication: 1999). We are getting a lot better at this.

Site suitability. Surveys conducted recently along the lower Colorado River recorded substantial areas where conditions for revegetation are suitable. Anderson (1995) reported that in 28 percent of his samples depth to water tables and salinity were suitable for cottonwoods and willows. Bureau of Reclamation (1995) found that 10 percent of the 18,762 acres of monotypic saltcedar stands surveyed were suitable for cottonwoods, 45 percent for mesquites, and 45 percent for quailbush—all valuable wildlife plants. Ten percent of the present monotypic saltcedar stands there totaled 4,446 acres, or approximately the amount of cottonwood/willow originally present. Some areas now may be too saline, or the water tables too low, for re-establishment and growth of cottonwoods and willows (but probably not for mesquite or quailbush), but these areas are smaller than is often implied. The assertion that extensive areas, including much actual or potential southwestern willow flycatcher habitat, are unsuitable for restoration to native vegetation has not been adequately documented. Controlled flooding, which prepares substrates, distributes seeds and dilutes salts, should be a component of promoting site suitability, especially in areas of high soil salinity.

Natural revegetation following floods. During the floods of the mid-1980s, large areas of saltcedar were washed out along the lower Colorado (B. Solomon personal communication: 1997) and middle Rio Grande, and certainly leached out some of the accumulated salts from the soils. Willows rapidly and naturally colonized in these areas and soon grew to a size suitable for wildlife habitat and remain so today, especially along the middle Rio Grande of New Mexico (D. Ahlers personal communication: 1997). The experimental flooding of the Grand Canyon in 1996 also leached out accumulated salts but did not scour out much saltcedar. The water table and salinity conditions there should be nearly ideal now for willows and cottonwoods except for the remaining direct competition from saltcedar.

At the Bosque del Apache National Wildlife Refuge on the Rio Grande of central New Mexico, successful natural revegetation has been routinely obtained by flooding areas cleared by mechanical control, and allowing the waters to recede just as cottonwoods are producing seeds; this produces almost a monoculture of cottonwoods. Coyote willow also has revegetated naturally around pond margins, and now form dense stands. The southwestern willow flycatcher now nests in the willows, whereas it did not nest here before the saltcedar was removed (J. Taylor personal communication: 1996). A large experiment in progress along streams in western Colorado to mimic the effects of the proposed biological control program through herbicidal applications and careful monitoring of vegetation recovery is showing success (D. Gladwin personal communication: 1999). Both native vegetation and bird usage have recovered well along some Mojave streams after Saltcedar removal followed by both active or passive vegetation restoration (B. West personal communication: 1999).

Thus, we simply do not agree that vast areas now infested by saltcedar cannot be returned to habitats dominated by native riparian species, and believe that it is imprudent policy to block the use of one of the most anticipated tools (classical biological control) for promoting this reversal. At all present major nesting sites of the southwestern willow flycatcher (with the possible exception of the Salt River inflow of Roosevelt Lake, which will be lost anyway by scheduled dam renovation) water tables and soil salinity are well within the range for growth of healthy willow and cottonwood stands. In fact, willows presently are growing at all these locations, and the lack of greater numbers of willows appears to us related to direct competition from saltcedar. Some areas in the southwest U.S. probably have become too saline or too dry for willows and cottonwoods but flycatchers are not presently nesting there.

Do Southwestern Willow Flycatchers Really Benefit from Saltcedar?

Flycatcher status and breeding habitat. Of the five subspecies of willow flycatcher (*E. traillii*), only the southwestern subspecies, *E.t. extimus*, is endangered. It apparently overwinters in Central America (Koronkiewicz et al. 1998), but in the breeding area of southern California to New Mexico it is considered a cottonwood/willow obligate species (Rosenberg et al. 1992). However, in mid-elevation areas of Arizona, southwestern willow flycatcher now nests significantly in saltcedar since saltcedar has replaced its native nest trees. It sometimes even appears to prefer saltcedar to the native willows for nesting (Sferra et al. 1997, McKernan and Braden 1999). It breeds in areas of dense shrubs or small trees with a dense (90 to 95 percent) canopy cover and often with a high upper canopy of cottonwoods, in moderate to broad floodplains (Hunter et al. 1987). The southwestern willow flycatcher usually nests within 100 meters of water in temporarily flooded areas, in branches overhanging water or near water or over wet ground, and if the soil dries out it may not nest or may abandon the nest. Narrow strips of trees only a few meters wide are not suitable nesting habitat (Tibbitts et al. 1994, Sferra et al. 1997). It nests in willow in many areas, but at other major sites it nests in coast live oak, boxelder maple or button bush, with a few nests in seepwillow baccharis or other native shrubs (Hull and Parker 1995, Skaggs 1996, Whitfield, 1996, Greenwald 1998, and others).

Total population size has declined severely to around 550 territories at 62 sites, with only seven known populations of more than 20 territories, but southwestern willow flycatchers still nest in most of its historic breeding range (R. Marshall personal communication: 1996), with the important exception of apparent extirpations from the lower Colorado north to Topock Marsh, the lower Gila to Roosevelt Lake and in western Texas (Sferra et al. 1997, Greenwald 1998, McKernan and Braden 1999). Since the invasion of saltcedar, the southwestern willow flycatcher nests significantly in it in Arizona but not in other areas (Sferra et al. 1997), and it is generally absent where saltcedar has replaced the native riparian vegetation (Tibbitts et al. 1994). Site fidelity by the southwestern willow flycatcher is high (Paxton et al. 1977), which may be a factor in tolerating sub-optimal habitat rather than abandoning a site.

A major population of about 23 pairs breeds in mixed willow/saltcedar stands at the Tonto Creek inlet at Roosevelt Lake (southcentral Arizona), and another roughly 20 pairs in monotypic saltcedar stands at the Salt River inlet—all nests were in saltcedar trees at both areas (Paradzick et al. 1999). Another population of circa. 20 pairs breed in Saltcedar at Topock Marsh on the lower Colorado River near Needles, California (McKernan and Braden 1999). This species appears to be opportunistic in selection of nest trees, basing choice on high canopy density (generally greater than 90 percent) and suitable vertical forked branching structure (Sferra et al. 1997, M. Sogge personal communication: 1997, DeLoach et al. in press). It seems that saltcedar is providing a reasonably adequate alternate habitat, but is it?

Detrimental interactions with saltcedar. Loss and fragmentation of native breeding habitat is given as the primary cause for the decline in southwestern willow flycatcher populations in nearly every discussion of the topic by flycatcher biologists (U.S. Fish and Wildlife Service 1995). One of the most widespread and obvious changes in habitat is the replacement of the native willow/cottonwood western riparian forests by invading saltcedar. During the past 60 to 70 years, saltcedar has increased to occupy half or more of the total vegetation on most southwestern streams and now exceeds 90 percent replacement on many. The southwestern willow flycatcher population decline over time, first noted by Phillips (1948), is correlated with the decline in native plant communities and increase in saltcedar over the same time period (Hunter et al. 1987, 1988, Rosenberg et al. 1991), although a causal relationship has not been proven. The southwestern willow flycatcher continues to breed well and even increase in several areas of native vegetation outside of Arizona, but populations have been extirpated from large ares of saltcedar-dominated habitat along the lower Colorado and lower Gila Rivers); no nesting is reported in similar areas outside the historic breeding range but on migration paths, like the Pecos River of Texas and New Mexico (Cooper 1997). For the most part, large monotypic stands of saltcedar seem to be unsuitable habitat (Tibbitts et al. 1994), perhaps in part due to the southwestern willow flycatcher's lack of preference for the extensive drier riparian areas that saltcedar now occupies and helped to create, or to the lack of critical food insects.

Nest parasitism by the brown-headed cowbird (*Molothrus ater*) is an important mortality factor for southwestern willow flycatcher (Tibbitts et al. 1994), and there are indications that parasitism may be greater in saltcedar-dominated areas than in native stands. On the Pecos River, the ratio of cowbirds to other birds was three times higher in saltcedar than in native vegetation types (Livingston and Schemnitz 1996). McKernan and Braden (1999) reported greater levels of cowbird parasitism in near monotypic Saltcedar at Topock Marsh (6 of 21 nests) than in near monotypic willows at Pahranagat NWR (0 of 21 nests). This may be owing to the less dense vegetative structure of the subcanopy nest sites compared with willows, and this may also make the nesting birds more susceptible to predation (Sogge and Tibbitts 1994, McDonald et al. 1995). Predators include common kingsnakes (*Lampropeltis getulus*), spotted skunk (*Spilogale gracilis*), and rodents that feed by visual cues (Paradzick et al. 1999, Greenwald 1998); 31.5 percent of nests reported by Paradzick et al. (1999) experienced predation.

It is suggested that lethal temperatures for eggs and nestlings in relation to vegetation type may play a role in the extirpation of the southwestern willow flycatcher in some low elevation sites where maximum temperatures regularly exceed 43 degrees Celsius (109°F) (Hunter et al. 1987, Rosenberg et al. 1991). Saltcedar thickets, coupled with the complete lack of a cottonwood overstory, allow temperatures to frequently exceed the lethal level for bird eggs during the summer. If the stomatal closure (Smith et al. 1998) during hot afternoons is greater in saltcedar than in willows—then the consequent reduced transpiration in saltcedar thickets would allow higher temperatures than in willows, comparisons that apparently have not been made. Anderson (1994) found that, in saltcedar/mesquite vegetation along the lower Colorado River, mean daily soil temperatures at the 10-centimeter depth were 2 to 5 degrees Celsius higher, and maximum daily temperatures were up to 10 degrees Celsius higher, than in a cottonwood/willow grove, presumably because of the greater amount of shade in the cottonwood/willow grove.

Southwestern willow flycatcher populations are susceptible to elimination by stochastic events like floods and fires especially since most populations are small and tend to occur in small areas. The increased likelihood of fire is one of the most serious threats to the southwestern willow flycatcher caused by saltcedar (Greenwald 1998). Fires are rare in native riparian plant communities, but saltcedar stands burn relatively frequently (Agee 1988), and the driest part of the year often is during the breeding season for these birds. In 1996, large fires in saltcedar stands at the PZ Ranch on the lower San Pedro River burned 75 percent of the habitat and several active nests (Paxton et al. 1996). A fire in saltcedar at Topock Marsh on the lower Colorado in 1998 burned much habitat and may have burned some active nests, and fires at Mittry and Martinez Lakes burned habitat with territories but no nests. The birds thus increase their risk of breeding failure by choosing to nest in saltcedar.

Individual breeding success. It is clear to all involved in this issue that the southwestern willow flycatcher is actively choosing saltcedar over native trees for nesting in numerous important sites. Observations even indicate that breeding pairs using saltcedar have nested more frequently in a single season than those using native vegetation (McKernan and Braden 1999). If so, we are concerned that such information is being interpreted as an indication of breeding success. A closer examination of the data used to justify the "protection" of saltcedar as, in essence, critical habitat shows that saltcedar may be having a negative impact on current breeding, not simply having been a factor in degrading native habitat in the first place.

During 1998, southwestern willow flycatcher surveys were conducted at 110 sites at 28 locations from the U.S./Mexico border to southern Nevada (McKernan and Braden 1999). Although data were not completely transparent, comparing fledgling success per breeding female at four sites with comparable nesting data (Topock Marsh, Virgin River, Pahranagat NWR, Meadow Valley), we (DeLoach et al. in press) found that pairs nesting in monotypic or predominant saltcedar habitats produced a average of 0.82 fledglings (n = 22 pairs) and those nesting in willows produced 1.89 fledglings per pair (n = 19 pairs). In other words, birds using willows had a reproductive fitness 2.3 times greater than those nesting in saltcedar! In Arizona, the most direct comparison of nesting success was at Roosevelt Lake, between the Tonto Creek inflow (mixed vegetation but large saltcedar dominant) and the Salt River inflow (monotypic, large saltcedar). Nesting success was greater at Tonto Creek every year from 1994 to 1997 (average 1.43 fledglings per adult pair) than at the Salt River inflow (average 0.72 per pair), or 2.0 times greater in mixed vegetation than in monotypic saltcedar (data compiled by Greenwald 1998). For reference, as direct comparisons between unrelated sites are not statistically valid tests, nesting success in willows at higher elevation sites (mostly Geyer's willow, no saltcedar) was 2.6 fledglings produced per pair in 1998, 1.3 times that at the lower elevation sites with moderate saltcedar (Paradzick et al. 1999). In California, nesting success in native vegetation varied from 0.97 to 2.0 fledglings per pair at two major sites without significant saltcedar (San Luis Rey and South Fork Kern Rivers) from 1994 to 1997; the San Luis Rey system is, however, instead infested by another invader, *Arundo donax*. At eight sites along the Rio Grande in New Mexico during 1996, 0.57 fledglings per pair were produced at three sites "dominated" by saltcedar, and 0.33 per pair at four sites with "some" saltcedar (data compiled by Greenwald 1998).

These data should be of great concern to wildlife managers, as reproductive success provides the best indication of the potential for populations to rebound or to continue a decline, and while lifetime reproductive fitness is harder to assess, annual reproduction of short-lived animals that is less than one replacement bird per year is probably not a good sign for a population.

It is likely that food availability will explain some of these differences.

Early studies indicate that the willow flycatcher (*E. traillii*) fed mostly on wasps and bees, beetles, flies and sometimes moths (including caterpillars) but not on Homoptera, which includes leafhoppers and cicadas (Beal 1912). Saltcedar supports a depauperate insect assemblage of exotic *Opsius* leafhoppers, numerous pollen and nectar feeders, and Apache cicada (Liesner 1971, Stevens 1985, Glinski and Ohmart 1984). The southwestern willow flycatcher feeds to a limited extent on *Opsius* leafhoppers but not on the Apache cicada, and caterpillars constituted 17 percent of the number of insects (23 percent by volume) in the diet of nestlings and 6 percent of the adult diet (Drost et al. 1998). Caterpillars (*lepidoptera*) are entirely absent from saltcedar. The diversity and abundance of insects is far greater on native riparian plants, and we believe that as the percent composition of native plants declines, site potential for production of a new generation of flycatchers will follow suit as a course of trophic and metabolic fact. Yong and Finch (1997) analyzed fat stores of willow flycatchers (mostly *E. t. extimus*) moving through the middle Rio Grande in New Mexico, and almost half had no observable fat; those caught in willow habitat had higher fat stores that those caught elsewhere, suggesting its metabolic usefulness to the resource-stressed birds. Paradzick et al. (1999) speculated that higher rainfall during the 1998 El Niño may have produced unusually high abundance of food insects leading to increased nesting success and productivity. The region has experienced abnormally high precipitation since the 1970s and is expected to soon re-enter the drier period of a multi-decadal cycle (Zhang et al. 1997); this does not bode well for the future of this bird unless management can increase the dominance of native vegetation and the biotic assemblage it supports.

Single-species Management in Endangered Ecosystems

This overview of issues related to the invasion of saltcedar into southwestern riparian ecosystems and its influences on native biodiversity is intended to validate the efforts of individuals and organizations throughout the region to control its expansion and reduce its dominance in our watersheds. The careful introduction of natural enemies should be considered as a legitimate and useful component of anintegrated pest management approach, including mechanical and chemical control methods in appropriate locations. Biological control has the potential to extend moderate control in a cost-effective manner into both remote sites where access is difficult yet biodiversity values are high, as well as in altered floodplain environments where the greatest saltcedar infestations are found but which would be prohibitively expensive to control using traditional methods. We encourage water and land managers to explore means of using manipulated flow regimes in regulated waterways to promote conditions more favorable to re-establishment of functional native riparian forests (Graf 1999, Gladwin and Roelle 1998), but this is not an easy endeavor (physically and politically), nor is it sufficient to reverse the continuing spread of saltcedar in the region. Nonetheless, many workers in this area agree that in the modern era a different approach to water management and biodiversity protection must be applied.

With that in mind, we also call for the re-evaluation of the goals and methods of endangered species professionals. The fact that a species, or subspecies in the case of the southwestern willow flycatcher, has declined to levels that justify listing as "Endangered" suggests that the environments it inhabits are seriously compromised, and we applaud the Flycatcher Recovery Team for an exhaustive job of analyzing a wide and complex range of factors that are potentially responsible; the most serious flaw to date, however, may be errors in evaluating the perceived (and, in our opinion insignificant) risks posed to the flycatcher by the introduction of biological control agents against *Tamarix* spp. That being said, increasing numbers of conservation scientists severely criticize the concept and practice of "single-species management" that is the strict interpretation of the Endangered Species Act, which puts an overriding focus on efforts to "save" a single rare species, to the general exclusion of the simultaneous planning to protect co-occurring fauna and flora (e.g., Pipkin 1996, Simberloff 1998, Moyle 1995, Noss et al. 1997, Towns and Williams 1993). Not only does it potentially doom associated species to continuing decline if the target species (southwestern willow flycatcher) is not a reliable indicator of overall quality of the ecosystem (cf. Finch 1999), but in ecosystems as dynamic as desert rivers and as subject to continuing invasion (as well as to fire and other stochastic events), it is not rational because the ecosystem cannot be held constant until all questions are answered.

Biodiversity "triage" is not only a rational policy, in this case we strongly feel thatno species will truly lose so that the term probably does not even apply. Of the 50-plus T&E aquatic and riparian species found in the desert regions infested by saltcedar, not a single one can be shown to benefit because of the presence of this weed, and in fact there are both good reasons and often good data to conclude that many would benefit from its reduction, and even eradication if that were possible. All of these species, including aquatic ones, should be studied and managed together because they depend upon similar hydrological regimes and environmental factors for sustained inhabitation. Many others are declining regionally and globally, and their lack of legal status only means that they haven't yet declined to the threshold where recovery becomes dramatically less probable. Even if the willow flycatcher nested as successfully in saltcedar as it does in native vegetation (and the data show otherwise), this is poor grounds for protecting a non-indigenous plant when the preponderance of species both listed and unlisted suffer from its continuing expansion. In fact, the rate of habitat loss due to this continuing invasion is far greater than the rate at which restoration is occurring, and delays in confronting this fact are misguided.

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The Silvio O. Conte National Fish and Wildlife Refuge Invasive Plant Control Initiative

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Controlling Invasive Species is Central to the Mission of the Service

The mission of the United States Fish and Wildlife Service (Service) is to conserve, protect and enhance the nation's fish, wildlife and plants and their habitats for the continuing benefit of people. Invasive species supplant native species reduce natural diversity, often deplete wildlife habitat value and sometimes alter the way an ecosystem functions. Service Director, Jamie Clark, recognized that, "invasive species are second only to habitat loss and degradation in their impact on our ability to conserve biodiversity." One of the Service's top four priorities in the years 1999 and 2000 is "leading efforts to prevent the introduction and spread of invasive species."

Controlling Invasive Species is Important to Accomplishing Conte Refuge's Purposes

The Service has several divisions to fulfill its mission, including Ecological Services, Law Enforcement, Fisheries, and Refuges and Wildlife. The Service has recently organized along geographic lines to encourage the divisions to cooperate with each other and outside partners to solve today's complex environmental problems. Invasive species control is a good example of a complex problem that must be approached from a broad geographic perspective because these species do not respect political boundaries as they spread. Controlling species on your own land is difficult if your neighbors do not on their land.

The Silvio O. Conte National Fish and Wildlife Refuge (Conte Refuge) is a new refuge with a similar broad geographic focus. In the refuge's founding legislation, Congress directed the Service to establish a refuge "to conserve, protect and enhance the natural diversity and abundance of plant, fish and wildlife species and the ecosystems upon which these species depend" throughout the 7.2 million acre (2.9 million ha) Connecticut River watershed. Refuge planners recognized that Service land acquisition alone could not adequately protect natural diversity; instead, most watershed acreage must be appropriately managed. To accomplish this, the Conte Refuge, in partnership with existing organizations, provides environmental education and technical and financial support for appropriate wildlife habitat management on public and private lands. The Conte Refuge encourages and empowers citizens to understand and solve the problems wildlife face. Addressing the threat to natural diversity posed by invasive species, wherever they occur, is integral to fulfilling the Refuge mission.

Pulling Together

Refuge staff knew that many organizations in the watershed were deeply concerned about invasive species, but did not have the time or resources to devote to the problem. Individuals and organizations that were beginning to look into the problem reported feeling overwhelmed. Each group working on the problem in isolation was wasting a good deal of time and energy starting from scratch. Much duplication of thought and effort was occurring due to inadequate information sharing. The organizations all agreed that having a person dedicated to coordinating their efforts would be helpful.

Refuge staff seized upon the opportunity when the Fish and Wildlife Foundation offered grants as part of the "Pulling Together Initiative." The grants were to help in the formation of local weed management area partnerships "to ease a coordinated national approach to funding and tool effective, long-term invasive plant management at the local level. The results of this endeavor will be the leveraged use of funds and efforts; the sharing of knowledge and experience among partners; and the sense of common purpose, by encouraging cooperation between public and private partners." We did not have staff available to develop a proper grant application, so we used the bootstrap method. A botanist with good communication skills was contracted to talk to partners, formulate a plan and write the grant application. Five partners pledged in-kind matches, and fifteen wrote letters of support for the project.

In August 1997, the National Fish and Wildlife Foundation funded the Connecticut River Watershed/Long Island Sound Invasive Plant Control Initiative. Plants were chosen as a focus because the groups and individuals dealing with invasive plants were, for the most part, entirely different from those dealing with invasive animals. The partners who dealt with plants struggled the most to organize.

The grant provided $20,000 to hire a coordinator to research and write a strategic plan, and $25,000 for high-priority control projects. A steering committee was formed, which included representatives of the Vermont Department of Environmental Conservation, the New Hampshire Department of Environmental Services, the Connecticut Department of Environmental Protection, the ad hoc Massachusetts Native Plant Advisory Committee, and the New England Wild Flower Society. This committee hired a coordinator and chose the high-priority control projects (Table 1). Members decided that the highest priorities were to protect endangered species populations that were being threatened by invasives and to control the first infestations of invaders new to the region.

Table 1. High-priority control projects completed.

Year	Cooperator(s)	Site location	Invasive species controlled	To protect/ prevent
1998, 1999	NHTNC and VT Natural Heritage	Connecticut river banks and islands, VT and NH	*Vincetoxicum nigrum*	Federally endangered plant, Jesup's milk vetch
1998	CTDEP	Falkner Island, coastal CT	*Phragmites australis*	Federally endangered roseate terns
1998	NEWFS	Floodplain, MA	*Lysimachia nummularia, Myosotis scorpioides*	State-listed plant
1998, 1999	CTDEP and Mason Island Fire District	Pond, Stonington, CT	*Hydrilla verticillata*	Remove first infestation in New England
1998, 1999	CTTNC and volunteer "Weed Masters"	TNC preserves	*Celastrus orbiculatus, Berberis thunbergii, Lythrum salicaria*	Controlled experiments on eradication methods
1998, 1999	VTTNC	Floodplain forest, VT	*Polygonum cuspidatum*	Major invader of riparian areas and elsewhere
1998	Town of Fairlee, VT	Lake Morey	*Myriophyllum spicatum*	Spread
1998, 1999	Holyoke Water Power Co., Holyoke Conservation Commission, MA Exec. Office of Env. Affairs, CTDEP	Log Pond Cove, CT River	*Trapa natans*	Remove first infestation in Connecticut River

Strategic Plan

The purpose of the plan was to describe the invasive plant problem in the Connecticut River watershed, compile information about the control activities that were already being accomplished, and recommend actions that would help organizations be more effective (individually and collectively) in controlling invasive plants.

A draft plan was produced in October 1998 and 207 copies were distributed for review. After revisions were made, a final plan was produced in March 1999. The plan is simple to follow. Chapter 1 discusses the problem plants and what information is available about their distribution, life history and control. Chapter 2 gives an overview of the activities of various agencies and organizations. Chapter 3 discusses findings and recommendations. Appendices include a detailed listing of activities by organization, an alphabetical listing of important contacts, a list of educational materials, a list of selected references about various plants, a summary of applicable pesticide regulations, examples of definitions and policies, and a discussion of the federal noxious weed list. Since March, more than 530 copies of the plan have been distributed, and the findings in Chapter 3 have been discussed at two regional conferences on invasive plants.

Implementing the Plan

Another grant was obtained from the Fish and Wildlife Foundation to retain the coordinator and start to carry out the plan. The following highlights the findings and recommendations of the plan and discusses the progress made on various recommendations.

Organization

Finding: New England is informally organized.

Many other regions of the country have had extensive experience dealing with farmland and rangeland noxious weeds. They already have county or state (and sometimes regional) regulations and control agencies to deal with the problem. New England, which is largely forested and has severe winters, has fewer noxious weed problems and no formal plant control infrastructure. The concern here has originated with managers of natural areas who see invasive plants usurping native plants and disturbing the ecology of natural areas.

Ad hoc organizations of interested agencies and organizations have formed independently in each state (Table 2).

Table 2. State committees.

Connecticut Invasive Plant Working Group
Maine Invasive Species Council
Massachusetts Native Plant Advisory Committee, Invasive Plant Group
New Hampshire has proposed legislation to create a committee
Invasive Plant Council of New York
Rhode Island Invasive Plant Steering Committee
Vermont Invasive Exotic Plant Committee

Recommendation: Establish a permanent centralized coordinating body.

Progress: New England Invasive Plant Group.

At a meeting in June 1999, representatives from seven states agreed to form a regional organization, and at a follow-up meeting in September, the 45-member New England Invasive Plant Group was organized (Table 3). The group's five primary functions are: to institute an early warning system to alert land managers to new problem plants; to work with state invasive species groups to create standardized lists; to exchange information and educational materials; to conduct meetings and conferences; and to identify research needs. The coordinator for the Invasive Plant Control Initiative is the staff for this group. The coordinator's first efforts for the group will be to create an email newsletter and organize a "share fair" for educational materials.

Lists

Finding: Lists of invasive plants are informal and controversial.

Most of the ad hoc organizations have listed invasive plants in their state. Eighty-seven different plants are found these lists. Thirteen of these plants are recognized as problems on four or more of the lists. The lists are based on the best professional judgement of the botanists and ecologists contributing to the list's compilation and review. The lists are difficult to compare because the professionals tend to categorize plants differently.

New Hampshire has the only "official" list, published by a state agency for regulating the plants on it. It contains largely aquatic invasive species and a handful of wetland species.

The nursery industry objects that plants are placed on lists without scientific evidence that they are serious problems. The industry fears that, though these lists have no regulatory significance, they could lead to regulation or other prejudice against the plants on the lists.

Recommendation: Work with the nursery industry to clarify definitions and criteria.

Table 3. Agencies and organizations participating in the New England Invasive Plant Group.

Connecticut Department of Environmental Protection, Natural History and Geological Survey, Office of Long Island Sound, Wildlife/Wetlands Habitat and Mosquito Management
Connecticut Invasive Plant Working Group
Connecticut River Joint Commissions
Connecticut River Watershed Council
Conway School of Landscape Design
Invasive Plant Council of New York
Maine Department of Agriculture
Maine Invasive Species Council
Maine Natural Areas Program
Massachusetts Audubon Society
Massachusetts Department of Environmental Management, Office of Water Resources
Massachusetts Department of Environmental Protection, Division of Watershed Management
Massachusetts Department of Food and Agriculture
Massachusetts Division of Fisheries and Wildlife, Natural Heritage Program
Massachusetts Native Plant Advisory Committee, Invasive Plant Group
National Park Service
New England Nursery Association
New England Wild Flower Society, New England, Plant Conservation Program
New Hampshire Department of Agriculture, Markets and Food
New Hampshire Department of Resources and Economic Development, Natural Heritage Program
New Hampshire Department of Environmental Services
New York State Office of Parks, Recreation and Historic Preservation
Northeastern Weed Science Society
Rhode Island Department of Environmental Management, Natural Heritage Program
Rhode Island Invasive Plant Steering Committee
Rhode Island Natural History Survey
Rhode Island Wild Plant Society
Society for the Protection of New Hampshire Forests
The Nature Conservancy of Connecticut
The Trustees of Reservations
University of Connecticut Cooperative Extension System, G. S. Torrey Herbarium, Dept. of Ecology and Evolutionary Biology
University of Massachusetts
U.S. Fish and Wildlife Service
USDA Forest Service, Northeastern Research Station, Northeast Area State and Private Forests
USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine
Vermont Department of Agriculture, Food and Markets
Vermont Department of Environmental Conservation, Nongame and Natural Heritage Program, Water Quality Division
Vermont Invasive Exotic Plant Committee
Weed Science Society of America

Progress: A working group representing all stakeholders has agreed on definitions and criteria and has begun to apply these to specific plants to develop an acceptable list.

A subcommittee of the Massachusetts Native Plant Group with broad representation from stakeholders (Table 4) has been formed to concentrate on invasive plant issues. The participation of all stakeholders will be positive because of the great potential for collaborative activities to control plants effectively. Participants decided that the first objective was to agree on particular species of plants upon which control and cooperative educational efforts should be focused. A smaller working group has met and agreed on definitions and criteria to be used to develop a list. The larger group has adopted the definitions and criteria. The smaller group is now beginning to apply the criteria to specific plants.

Inventory and Monitoring

Finding: Inventory and monitoring for upland invasive plants is inadequate.

Monitoring for invasive aquatic plants is being done by state agencies and volunteers. Aquatic invasive plants like Eurasian water milfoil (*Myriophyllum spicatum*) impact the recreational uses of lakes and ponds, and they reduce lakeside property values. Citizens have demanded inventory and control of invasive aquatic plants. There are no large-scale projects to identify the distribution of invasive upland plants; this is only being done by landowners on specific parcels. Herbaria records and Natural Heritage databases are biased to record the occurrences of rare species more accurately than occurrences of common species.

Recommendation: Construct a regional atlas and early detection system.

A large scale systematic "atlas" of the region should be constructed to provide a better understanding of the distribution of invasive plants, how they are spreading, and to provide early detection of new infestations. More inventories that can feed information into the atlas should be encouraged.

Progress: Partners are ready to begin but need funding.

The University of Connecticut has proposed to develop an online, continuously updated atlas. This atlas would show historic data on distribution garnered from herbaria records plus current data from ongoing inventories. The Invasive Plant Control Initiative coordinator is writing grant applications to secure funding for this effort.

Table 4. Membership of Massachusetts invasive plant working group.

Government Agencies	
	United States Fish and Wildlife Service, Conte Refuge
	Massachusetts Division of Fisheries and Wildlife, Natural Heritage Program
	Massachusetts Division of Fisheries and Wildlife, Biodiversity Initiative
	Massachusetts Highway Department
	Massachusetts Metropolitan District Commission, Watershed Management
	Massachusetts Department of Food and Agriculture
	Massachusetts Farm Bureau
	Metropolitan District Commission
	Boston Parks Department/ Urban Wilds Program
	Cape Cod Commission
Conservation Organizations	
	Massachusetts Association of Conservation Commissions
	Massachusetts Audubon Society
	New England Wildflower Society
	The Nature Conservancy—Massachusetts Chapter
	The Trustees of Reservations
Professional and Amateur Organizations	
	Associated Landscape Contractors of America
	Association of Professional Landscape Designers
	Ecological Landscaping Association
	Garden Club Federation of Massachusetts
	Massachusetts Arborists Association
	Massachusetts Association of Professional Foresters
	Massachusetts Nursery and Landscape Association
	New England Landscape Association
	Northeastern Weed Science Society
	Worcester County Horticultural Society
	National Council of State Garden Clubs
	Society for Ecological Restoration, New England Working Group
Educational and Research Institutions	
	Conway School of Landscape Design
	University of Massachusetts Cooperative Extension System
	University of Massachusetts Biology Department
	Horticultural Research Institute
	Arnold Arboretum of Harvard University
	Berkshire Botanical Garden
	Tower Hill Botanical Garden
Businesses	
	Bigelow Nursery
	New England Wetland Plants
	New England Environmental, Inc.
	Sylvan Nurseries
	Tranquil Lake Nursery
	Vegetation Control Services
	Weston Nurseries

Control

Finding: Concentrate on the possible.

Most well-established invasive plant species and populations are here to stay; wide-scale eradication is not being considered. Wide-scale control of well-established populations of invasives takes considerable research, coordination and continuous funding over many years. In New England, concerted efforts are only being made to control phragmites (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*) and some aquatic species.

Initiative partners agree that preventing new invasive plants from becoming established in the Connecticut River watershed/Long Island Sound area is a high priority and organizations should cooperate in controlling such new infestations. Protecting endangered and rare species, and pristine natural communities, from invasives is also a high priority.

The key to preventing new invasive plants from becoming established is recognizing which little-known plants have the *potential* to become the worst problems in this region, and knowing which of these are already established in nearby areas and could spread into our region.

Recommendation: Partners should cooperate to accomplish high priority projects.

The coordinator should seek funding for high priority projects. Landowners should be encouraged to identify and eradicate new infestations of certain plants that will cause them problems.

Progress: Partners are working together to control the spread of new invaders and plants threatening rare species.

Because the grant paid on a reimbursement basis, Conte Refuge had to advance funds from its budget to accomplish the 1998 control projects. It then used the reimbursement to fund a second year of many high-priority projects (see Table 1). In addition, the Refuge and several of its partners have been cooperating to control the first infestation of water chestnut (*Trapa natans*) on the Connecticut River. This infestation, in Holyoke, Massachusetts, was controlled in 1998 and 1999. Monitoring and public outreach also were put in place to search for any other infestations. As a result, four small populations nearby in Massachusetts were discovered and controlled in 1999. Two populations also were discovered in Connecticut. One was small enough to be controlled by hand-pulling in 1999. Machine-harvesting of the other will begin in the 2000 field season. Discovering and controlling this plant while numbers are low enough for hand-pulling is the key to stopping its spread. Partners will continue monitoring and public outreach efforts.

Research

Finding: Lesser known plants need to be researched.

While there is information on some plants widely recognized as invasive, there is very little information available on many other plants known or suspected to have great invasive potential. This lack of information on invasive potential and control techniques hinders stopping new infestations while they are still small. Good information on all suspect plants is necessary if the regional preemptive control strategy is to work.

Recommendation: Initiative partners should agree on priority plants to research.

This is a prime area where cooperation can eliminate duplication of effort. The partners should agree on which plants need to be researched, and then do literature searches, formulate specific research questions, and try to interest researchers in these questions. Land managers should share even anecdotal information on the success and failures of treatments through a newsletter.

Progress: The New England Plant group has agreed to prioritize the plants.

Education

Finding: There is difficulty convincing the public that there is a problem.

Citizens without a direct interest or experience in protecting natural areas do not see or remain unconvinced of the threat. Even if people agree that these plants will cause widespread displacement, they do not see it as a major problem. This problem is not perceived to directly impact public health the way air or water pollution does. Even land managers in areas with fewer invasive plants (for example, forest managers in the northern watershed), whose resources could benefit greatly from simple prevention programs, are complacent. The information needed to convince skeptics of the adverse impacts of invasive plants is inadequate.

Many diverse groups are various many things to educate the public about invasive species. However, they are using a scattershot approach.

Recommendation: Collect and publish case studies that clearly illustrate problems and cooperate on developing and sharing educational materials.

Problems that invasives are causing need to be properly documented. This would build a body of convincing evidence about the serious impacts of the problem.

Educational programs and materials need to be developed for specific, targeted audiences (for example, foresters, landscape architects, conservation commissioners, and purchasers at garden centers and pet shops). These programs should be developed cooperatively with the appropriate partners (i.e., the nursery industry and society of professional foresters). Materials should be shared instead of developed anew by each group.

Progress: Many partners have started working on education. The New England Plant Group has agreed to do more work on this.

The Refuge contributed to three conferences held in the region. The first was organized by Yale University's School of Forestry and Environmental Studies. It highlighted recent research findings on the ecology of invasive plants. The second was organized by Wesleyan University and concentrated on policy. The third was organized by the New England Wild Flower Society; it concentrated on control techniques.

Regulation

Finding: The New England States have few policies or regulations in the place to control invasive plants.

Few agencies and organizations have formal policies in place. The need to obtain permits for invasive plant control activities can take a good deal of time and energy. Only some states have laws regulating invasive aquatic plants. There are no laws in place regulating the importation, sale or distribution of upland invasive plants. Overall, horticultural businesses oppose such legislation.

Recommendation: Encourage the development of appropriate policies and regulations or appropriate alternative actions.

All organizations, especially those actively planting plants, like state departments of transportation, should be encouraged to adopt a policy prohibiting the planting of invasive plants and encouraging the planting of native alternatives. States should review laws to see if they may be amended to exempt invasive control projects from certain permits, or prepare generic environmental impact reports to help applicants prepare and commissions evaluate permits.

States should consider adopting new laws. At the same time, initiative partners and horticultural business representatives should discuss voluntary, cooperative alternatives to legislation. For example, regulations banning the sale of certain plants could be avoided if horticultural businesses agree to phase them out.

Progress: The Connecticut Invasive Plant Working Group is working on policies, regulations and actions in Connecticut.

Summary

The process of developing the plan greatly improved communication among many groups, especially among the invasive plant committees in Connecticut, Vermont, Massachusetts and New York and the New England Plant Conservation Program. The formation of the New England Invasive Plant Group ensures that this improved communication will continue.

There also have been major strides forward by the Massachusetts Native Plant Committee to include all stakeholders in discussion and collaboration. Their new invasive plant subcommittee has representatives from the nursery industry, professional landscaping associations, agricultural interests, plant control companies, professional foresters, conservation commission associations, and arboretums. This group is making progress on developing a consensus list of invasives that could be the basis of further cooperative educational and control efforts.

The partners are making progress in stopping the advance of several new invaders to the region. Pulling together works!

CALFED Nonnative Invasive Species Program

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The CALFED Bay-Delta Nonnative Invasive Species Program is a part of the CALFED Bay-Delta Program (Program). The Program began in May 1995 as a cooperative, interagency effort to address the tangle of complex problems that surround the San Francisco Bay-Delta estuary. It includes a large ecosystem restoration effort that presents both the opportunity and the need to address the problem of nonnative invasive species. I would like to share the experience of working on the NIS issue within a broad restoration program and describe some effective strategies and lessons learned.

Invasions by nonnative species has become one of the priority issues for resource management and conservation biology. Nonnative invasive species (NIS) are now recognized as a major threat to endangered and threatened species, second only to habitat destruction (Mac et al. 1998). Exotic, alien, introduced, nonindigenous or NIS are all terms often used to describe organisms that have been moved outside their native range through human activities and successfully have established populations. The consequences of such invasions may include alteration of population, community and ecosystem structure and function, economic costs and even threats to human health. The total economic impact of NIS on the U.S. economy is estimated to be about $122 billion annually (Clark 1998). Many ecologists now believe that NIS is the most serious and least appreciated threat to biodiversity, often resulting in the loss of native species. Many NIS interactions can contribute to detrimental conditions for native species and habitats such as predation, competition, habitat alteration, trophic alteration, spatial alteration, gene pool deterioration, introduction of diseases and parasites, and contaminant dynamics. As human mobility has accelerated over the last century, the frequency and number of NIS introduced has coupled with reduced travel times to result in increasing rates of introduction, survival and establishment of NIS. It is estimated that there are more than 6,500 established, self-sustaining NIS in the United States (Office of Technology Assessment, 1993). This is especially disturbing in light of evidence that only 5 to 10 percent of NIS become established and only 2 to 3 percent are able to expand their ranges (di Castri 1989).

The San Francisco Bay/Sacramento-San Joaquin Delta estuary (Bay-Delta), a maze of tributaries, sloughs and islands, is the largest estuary on the

West Coast. The Bay-Delta, more than 738,000 acres and 1,000 miles of waterways, is a haven for plants, terrestrial wildlife and fisheries resources. Historically, the Bay-Delta was a vast wetlands teeming with fish and wildlife. The species diversity includes more than 400 plants, 225 birds, 52 mammals, 22 reptiles and amphibians, and 130 fish. Millions of birds migrate through and live in the Bay-Delta. Historically, this system was highly variable, with seasonal patterns of freshwater inflow and tidal fluctuations. The Delta supported extensive wetlands, including ponds, sloughs, marshes, and a riparian zone along the rivers as wide as 40 miles. The watershed system drains more than 61,000 square miles or 37 percent of the state. The biological health and biodiversity of the system depend on the quality, quantity, timing and distribution of the water that flows through the estuary.

The earliest recorded assault on this system began in the 1850s with the unrestricted use of hydraulic mining, which filled channel beds and shallow areas with sediment. As settlement occurred throughout the 19th and 20th centuries, lands were reclaimed, levees erected and rivers were channelized and dammed to create fertile farmland and urban areas, store water and reduce flooding. More than 700,000 acres of overflow and seasonally inundated land in the Delta have been converted to agricultural or urban use. More than 95 percent of the original tidal wetlands have been eliminated. Dams now block all of the major rivers feeding into the estuary.

The Bay-Delta is the hub of California's two largest water-distribution systems and at least 7,000 other permitted diverters have developed water supplies from the watershed feeding the Bay-Delta estuary. Together these water development projects divert 20 to 70 percent of the natural flow in the system, depending on the amount of runoff available. The watershed is critical to California's economy, supplying drinking water for 22 million Californians and irrigation water to fields that grow 45 percent of the nation's produce.

The need for water for these other uses often competes with the environmental water needs. Although all agree on the importance of the Bay-Delta estuary for habitat and as a reliable source of water, few agree on how to manage and protect this valuable resource. There is a rich history of conflict in the Bay-Delta system with competing interests such as ecology, economy, urban growth and agriculture battling over the resources of the region for decades, resulting in disagreements that have increasingly taken the form of protracted litigation and legislative battles. Water diversions, along with the effects of increased population pressures, NIS and numerous other factors have had a serious impact on the fish and wildlife resources in the Bay-Delta estuary. The Delta ecosystem no longer provides the habitat quantity and quality necessary to sustain the fish, wildlife and plants that depend on the system to survive. As a result, the Bay-Delta system has witnessed a decline of wildlife habitat, the threat of extinction of several native plant and animal species, the collapse of one of the richest commercial fisheries in the nation, the degradation of water quality, continued land subsidence of Delta islands, and an unreliable levee system. Progress on water-related issues had become mired, approaching gridlock.

The Bay-Delta has the dubious distinction of being known as the most invaded aquatic ecosystem in North America. More than 212 aquatic introduced species were documented in a 1995 report sponsored by the U.S. Fish and Wildlife Service (Cohen and Carlton 1995). Many of these species are believed to have arrived in the ballast water of ships. This problem has grown over the past 30 years as trade with Pacific Rim countries has increased. Since 1970, many new species of zooplankton, clams, crabs, amphipods, fish and plants have become established in the estuary and watershed. In parts of San Francisco Bay, a staggering 99 percent of all biomass is thought to be NIS (Eserink 1999). Some examples on the NIS of concern follow.

The spread of nonnative flowering aquatic plants has increased dramatically in California over the past 25 years and has created many economic and ecological impacts. Demands on the state's water resources, which include irrigation water delivery, recreational and domestic (drinking) uses, and fisheries and waterfowl habitats, have exacerbated these impacts. The aquatic plant species of most concern are: water hyacinth *(Eichhornia crassipes)*, Egeria *(Egeria densa)*, and Eurasian water milfoil (*Myriophyllum spicatum*). There is also an intensive Hydrilla (*Hydrilla verticullata*) control program underway to limit the spread and reduce the impacts from this aquatic plant. Water hyacinth has been under management for 15 years, and a bill authorizing the management of Egeria passed the state legislature in 1996. The combined costs of these efforts to control fewer than 25 percent of the infestations will probably equal or exceed the $1 million annual Hydrilla eradication expenditures.

Smooth cordgrass (*Spartina alterniflora*) introduced from the Atlantic coast has spread very rapidly in Pacific estuaries in northern California, Oregon, Washington and British Columbia and now invades the San Francisco Estuary. It is known now to hybridize with *Spartina foliosa*, the native cordgrass in the bay, which confounds the problem of identification and eradication. Smooth cordgrass and other cordgrasses are a substantial threat to wildlife, fisheries and traditional uses of Pacific estuaries. By replacing the naturally open mud of Pacific estuaries with monospecific grass prairie, the dense canopy and tightly interlocked rootmats of these weeds exclude shorebirds, native vegetation, fish, and many invertebrates. Pepperweed (*Lepidium latifolium*) is another particularly aggressive invader that is proving difficult to eradicate or manage in the watershed.

Recent introduction and spread of purple loosestrife *(Lythrum salicaria)* threatens the state's riparian systems. This notorious invader has recently been observed invading the Delta. Giant reed (*Arundo donax*) is widespread throughout the CALFED problem and solution areas and is now known to aggressively displace native riparian vegetation. It is very disruptive, affecting water quality and quantity, exacerbating flooding, and altering the geomorphology of the waterways it invades. Other plants that threaten our riparian or wetland systems include blue gum eucalyptus (*Eucalyptus globulus*), saltcedar (*Tamarix* spp.), Russian olive (*Eleagnus angustifolia*), Himalayaberry (*Rubus discolor*), Cape ivy (*Delairea odorata*; formerly known as German ivy, *Senecio mikanioides*), hoary cress (*Cardaria draba*), tree of heaven (*Ailanthus altissima*) and thistles (*Cirsium arvense* and *C. vulgare*).

Terrestrial nonnative invasive plants occupy most of the watersheds that drain into the major rivers of the Bay-Delta. Many of these watersheds have undergone wholesale "type-conversions" from their native vegetation type into exotic annual monocultures derived from plants of the Mediterranean region. Yellow starthistle (*Centaurea solstialis*) is an Eurasian invader which now covers 10 million acres in the greater CALFED watershed. This weed, with an exceptionally deep taproot, has been shown to absorb and transpire millions of gallons of soil moisture which would have otherwise entered the groundwater. Yellow starthistle degrades recreational open spaces, out competes native plants and useful forage species, and takes away habitat for ground nesting birds and other wildlife. (S. Schoenig, personal communication, 1999)

Italian thistle (*Carduus pycnocephalus*), black mustard (*Brassica nigra*), wild fennel (*Foeniculum vulgare*), and tree of heaven (*Ailanthus altissima*) are among other examples of damaging invasive nonnative plants which have become wide-spread in the interior watersheds of California. Examples of some troublesome weeds in the upper watersheds are: spotted knapweed (*Centaurea maculosa*), leafy spurge (*Euphorbia esula*) and Dalmatian toadflax (*Linaria dalmatica*).

The small Asian clam (*Potamocorbula amurensis)* first appeared in 1986 and since then has successfully colonized the brackish water portion of the estuary throughout San Francisco Bay to the western edge of the Delta. It became the dominant bivalve in the south bay by 1991 and has affected the base of the food web by removing much of the algae, which is food for zooplankton. This clam is so abundant that calculations indicate that the population can filter a volume of water equal to the entire water column in 24 hours. It has apparently greatly reduced abundance of the native copepod *(Eurytemora affinis)*, a dominant zooplankton species providing food for many larval fish.

The new mysid (*Acanthomysis bowmani)* was first reported here in 1993 and has since increased in abundance, while the native mysid *(Neomysis mercedis)*, another important food item for young fish, has been greatly reduced in abundance, perhaps through competition for food with the Asian clam.

Two exotic crabs, the Chinese mitten crab (*Eriocheir sinensis)* and the green crab *(Carcinus maenas)* have also become established in the estuary. The mitten crab, first found in South San Francisco Bay in 1992, has migrated hundreds of miles through the system, both upstream in the Sacramento River to the north and in the San Joaquin River to the south and throughout the tributaries. Some of the negative impacts that may be associated with this species include damage to rice crops, competition with crayfish, and burrowing into levees and banks. The green crab inhabits the intertidal zone, where it may compete with shorebirds and other crabs for food; it is a voracious predator of shellfish and native shore crabs. It is believed to have spread rapidly from San Francisco Bay, where it was first captured in 1989 or 1990 (Cohen and Carlton 1995), up the coast of California to Willapa Bay and Grays Harbor, Washington, and by 1999, well into the waters of British Columbia.

A number of introduced fish have become established in this estuary over the past 100 years, including striped bass, catfish and several members of Centrarchidae. Some of these fish now support popular fisheries and are considered by many to be a valued recreational feature of the watershed. Outside of the Sacramento-San Joaquin Delta, unauthorized planting of the Inland silverside (*Menidia beryllina)* occurred in 1967, and it was likely dispersed into the Delta from high winter flows and established there by 1975. It is suspected to prey upon larvae of other fish and may compete for food with the delta smelt (*Hypomesus transpacificus)* a threatened species. The delta smelt is also faced with the threat of hybridization and competition from a morphologically similar introduced smelt species, the wakasagi (*Hypomesus nipponensis)* (Fuller 1999). Another growing problem in California is ill-advised anglers who desire and introduce exotic species. The white bass *(Morone americana),* a species native to the Midwest, was eradicated from a reservoir with rotenone in 1987. Northern pike *(Esox lucius)*, another species native to the Midwest, was illegally stocked into a reservoir in the 1980s and in March 1991 the Department of Fish and Game treated the reservoir to successfully eradicate northern pike. A similar program was conducted in 1997 to eradicate northern pike from Lake Davis. These eradication efforts cost over a million dollars each. Late in 1999, northern pike were again confirmed in Lake Davis and work is now underway on another control plan. Biologists are concerned that if such predatory fish species become established in the watershed, they could decimate populations of threatened and endangered fish species, as well as other fish.

Nonnative wildlife is present throughout the Sacramento-San Joaquin Valleys in a variety of habitats resulting in diminished abundance of native species. One of the common but harmful mammal species found in the Bay-Delta area includes the European red fox (*Vulpes vulpes*), which threatens many native endangered wildlife species, such as the clapper rail (*Rallus Longirostris*

Obsoletus) and several other San Joaquin Valley animals. The Norway rat (*Rattus norvegicus*), which threatens ground-nesting wildlife, has experienced large increases in the populations living along the bay shores. The feral cat (*Felis catus*) is a major predator to bird and mammal populations in the wetland areas of the Bay-Delta estuary.

With this short summary, you can see that the NIS problems in the Bay-Delta are extensive. When combined with the other issues confronting the region, the justification for an extensive, cooperative, rehabilitation approach is evident.

The CALFED Program was formalized with the 1994 signing of a Framework Agreement which initiated a new dedication to state/federal cooperation in the Bay-Delta. The Program consists of state and federal agencies with management responsibilities for the Bay-Delta and also benefits from the collaborative efforts of representatives from other agencies and representatives from agriculture, urban, environmental, fishery, business and rural county entities. The member agencies provide policy direction and oversight for the CALFED process. These agencies are: State of California—Department of Fish and Game, Department of Water Resources, California Environmental Protection Agency, State Water Resources Control Board;

Federal—Bureau of Reclamation, Fish and Wildlife Service, Environmental Protection Agency, National Marine Fisheries Service, U.S. Army Corp. of Engineers, Natural Resources Conservation Service.

The mission of the CALFED Bay-Delta Program is *to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system.* The Program objectives are based on the main problem areas:

- provide good water quality for all beneficial uses;
- improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species;
- reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system; and
- reduce the risk to land use and associated economic activities, water supply, infrastructure and the ecosystem from catastrophic breaching of Delta levees.

The CALFED Program agreement included a commitment by agencies and stakeholders to develop and fund non-flow related ecosystem restoration actions to improve the ecological health of the Bay-Delta while development of the long term solutions continues. Some specific actions to be addressed include unscreened water diversions, waste discharges, water pollution, fishery impacts due to harvest and poaching, NIS, fish barriers, channel alterations, loss of riparian wetlands, and other causes of estuarine habitat degradation. The Ecosystem Restoration Program (ERP) is the element of the CALFED Program focused on restoring the health of the Bay-Delta ecosystem and responsible for carrying out this "early implementation." The ERP utilizes an ecosystem-based management approach that emphasizes the rehabilitation of natural processes to create and maintain habitats. The goal of the ERP is *to improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species.*

A Strategic Plan for Ecosystem Restoration has been developed to provide a framework and consistent guidelines for implementation of ERP. This Plan emphasizes the importance of the ecosystem approach and adaptive management. The following are the six goals of the ERP.

1. Achieve recovery of at-risk species dependent in the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species. Support similar recovery of at-risk species in the San Francisco Bay and the watershed above the estuary.
2. Rehabilitate the capacity of the Bay-Delta system to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities, in ways that favor native organisms.
3. Maintain and enhance populations of selected species for sustainable commercial and recreational harvest, consistent with goals 1 and 2.
4. Protect or restore functional habitat types throughout the watershed for public values, such as recreation, scientific research and aesthetics.
5. Prevent establishment of additional NIS and reduce the negative biological and economic impacts of established nonnative species.
6. Improve and maintain water and sediment quality to eliminate, to the extent possible, toxic impacts on organisms in the system, including humans.

ERP began implementation of ecosystem restoration projects beginning in 1997. To date CALFED has funded 195 projects, for a total investment of approximately $228 million. Approximately 75 percent of these funds have gone to restoring rivers, riparian forests, wetlands and marshes. The remainder has gone to such projects as installing fish screens on water diversions, NIS, and research. Many of the ERP projects selected for funding also benefit other CALFED objectives such as water supply reliability, levee system integrity and water quality.

The ERP Strategic Plan recognized that NIS may be the greatest impediment to restoration success. At CALFED's request, the U.S. Fish and Wildlife Service accepted the responsibility of developing, implementing and coordinating a Nonnative Invasive Species Program. This program, initiated in October 1999, is a cooperative effort, drawing on the expertise and experience of agencies, scientists, and interested stakeholders to focus on prevention and control of NIS in the Bay-Delta watersheds.

Building on the examples of other CALFED programs, work teams were formed to develop the NIS program with invitations extended to all of the CALFED agencies and other interested scientists and stakeholders. Meetings are generally held every other month with much of the work accomplished via email and telephone. The first task of the Program was to develop a NIS Strategic Plan. Rapid development of this Plan was possible because of the assistance of a group of state agency representatives that had been working on a state plan, led by the California Department of Food and Agriculture. The goals of the NIS Strategic Plan are:

I: preventing new introductions and establishment of NIS into the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin Rivers and their watersheds;

II: limiting the spread or, when possible and appropriate, eliminating populations of NIS through management; and

III: reducing the harmful ecological, economic, social and public health impacts resulting from infestation of NIS through appropriate management.

Once the draft Strategic Plan was approved by all team members and reviewed by some other CALFED entities, work began on a draft Implementation Plan, which details specific actions and tasks that are desirable and necessary. Once this draft Plan also had undergone extensive review and comment, the work teams focused attention on the identification of priority projects. The ERP Strategic Plan and goals of the NIS Strategic Plan formed the basis for decisions about directed projects and support for projects submitted through an open request for proposals. The NIS Program identified seven directed projects to support with Program funds. In general, these projects met the objectives and goals of the ERP and NIS Strategic Plans, addressed issues of immediate concern that had been largely neglected, and stimulated commitment and cost share by entities appropriate to address the issues. The topic areas addressed by these projects included: Purple Loosestrife Prevention and Eradication; Zebra Mussel Detection and Outreach; Reducing the Risk of Importation and Distribution of Nonnative Invasive Species Through Outreach and Education; Spartina Eradication Project; Practical Guidebook to Prevent and Control Nonnative Invasive Plants in Shallow Water Habitats of the Bay-Delta Ecosystem; Effects of Introduced Clams on the Food Supply of Bay-Delta Fish; and Nonnative Invasive Species Advisory Council.

Four NIS projects were also selected for FY99 funding from a request for proposals and three more NIS projects will be funded with FY00 funds. These projects include: Purple Loosestrife Prevention and Eradication, Phase II; Effects of Introduced Clams on the Food Supply of Bay-Delta Fish Species, Phase

II; Assessing Ecological and Economic Impacts of the Chinese Mitten Crab; Evaluation of the Potential Impacts of the Chinese Mitten Crab on the Benthic Community in the Delta; *Arundo donax* Eradication and Coordination; Treating Ballast Water Discharges at Existing Municipal Wastewater Treatment Plants; and Determining the Biological, Physical and Chemical Characteristics of Ballast Water Arriving in the San Francisco Bay/Delta Estuary.

All project proposals have gone through a stringent requirements evaluation, technical review, and stakeholder and agency review prior to approval. It is also important to note that these projects, as a package, address the various issue areas of prevention, control and eradication. The strategies employed to implement the projects include management, research, mapping, monitoring, outreach and education, and coordination. In fact, in some instances all of these strategies are included in one project (Spartina and Loosestrife). It is anticipated that the work resulting from this package of projects will demonstrate the value and importance of working to address NIS issues and concerns as part of restoration programs. There is serious risk associated with ignoring NIS issues in restoration programs because NIS may interfere with actions and hinder the efforts of restoration programs both directly and indirectly.

In general, the NIS Program enjoys the broad-based support of a wide range of interest groups. There is some concern that we have not been able to move quickly enough to address the problems. But with very real constraints of consensus and funding, the accomplishments to date are impressive, although there is much room for expansion and improvement of the NIS Program.

Providing insight into some of the "lessons learned" may provide immeasurable benefits to others seeking to model NIS Programs on the CALFED efforts. The first lesson we have learned is that we need is to improve coordination and cooperation efforts. There is a wealth of information and activity "out there" and partners abound in some unlikely places. It is important to realize that agencies can not do it alone. Include individuals with NIS expertise on boards or teams which are developing plans, priorities, solicitation packages and projects. These types of work team activities will guide the program implementation. To maintain integrity, it is very important to clarify conflict of interest guidelines for work team participants. Structure work team tasks to reduce monopolizing.

We are currently working on an NIS issue paper, which can be an especially valuable tool for prioritizing management actions, evaluating proposed actions, prioritizing scientific needs, and identifying realistic NIS targets.

When developing agreements and providing contract management for the NIS projects, it is essential to maintain close coordination and ensure timely information relay for the benefit of the adaptive management process and success of the projects.

Preventing introductions of NIS is much more protective, economical and environmentally friendly than control or eradication programs.

Monitoring programs must be tailored to address the early detection of NIS. This will enable the development of "rapid response" programs that can address initial invasions quickly, economically and with as little disruption as possible. Timely intervention is less expensive and disruptive.

As we continue to build the knowledge base on NIS, we will continue to expand our understanding of the NIS problem and better ways to address the issues. Unlike an oil spill or a dam, we often are not able to "clean up" or "remove" the NIS offender. Evaluating the permanence and impacts of the alterations due to invasions may be an arduous task. We know that we can not ever come close to returning the Bay-Delta to the conditions of 50 years ago. The ecosystem has been forever altered by NIS in ways not yet explored. As we attempt to improve conditions, we must work diligently to prevent further degradation and homogenization of the ecosystem and it's biota due to invasions of NIS.

The challenges of the NIS issue are great and the needs many. A comprehensive, interdisciplinary approach to issues of policy development, coordination, education, resources, research, legislation and enforcement will be required to solve the multitude of NIS problems.

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Nutria: A Nonnative Nemesis

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Wetlands and tidal marshes throughout the lower Eastern Shore of Maryland have rapidly declined over the last few decades. For example, at least 7,000 of the Blackwater National Wildlife Refuge's 17,000 acres of marsh have been lost (G. A. Carowan personal communication: 2000). Resource managers believe that without intervention these wetlands, which provide significant ecological, cultural and economic benefits to the state of Maryland, the Atlantic Coast and the nation, may completely disappear within the next decade. For example, on a local level, Blackwater National Wildlife Refuge, generates approximately $15 million annually in tourism revenue for Dorchester County (W. Roache personal communication: 1998). Tourists visit Dorchester County and other areas on the Eastern Shore to enjoy the native wildlife and natural wetland areas; however, the continued existence of these precious resources is currently threatened.

The decline of wetlands and tidewater marshes is due to several factors, including sea level rise, land subsidence, increased salinity and herbivory by an introduced, non-native species, the nutria (*Myocastor coypus*). Nutria are large, surface-feeding herbivores that can be extremely destructive to marsh vegetation. Nutria were first introduced in the United States in California in 1899 (Willner et al. 1979). Subsequently, they were introduced in 22 states nationwide (LeBlanc 1994, Hesse et al. 1997), including Maryland (in 1943), and now are established in 15 states (D.L. Bounds unpublished data). Although managers have little if any control over factors such as sea level rise, land subsidence or increased salinity, they may be able to act to control problems caused by nutria.

Nutria forage directly on the vegetative root mat, leaving the marsh pitted with digging sites and fragmented with deep swim canals. In the face of rising sea levels, nutria damage is particularly problematic because it accelerates the erosional processes associated with tidal currents and wave action. The situation is extremely delicate within the tidal marshes of the Blackwater River because much of the marsh is underlain by a layer of fluid mud that is easily washed away once the vegetation becomes fragmented. The cumulative result of an overabundance of nutria and rising sea level at Blackwater National Wildlife Refuge has been a rapid conversion of emergent marsh to open water.

There are no natural predators to control nutria, so populations have exploded. Maryland's native muskrat (*Ondatra zibethica*) populations are threatened by competition from the non-native nutria and loss of habitat (R. C. Colona personal communication: 2000).

Nutria reproduce throughout the year, having two to three litters annually (Brown 1975, Willner et al. 1979); litter size averages five young, but females may have up to 13 young per litter (Nowak 1991). Although nutria were introduced to support the fur industry, demand for fur has not kept pace with the animal's ability to reproduce. From a fur trappers perspective, nutria are less valuable than other furbearers such as the native muskrat because only a portion of the nutria pelt is usable, the quality of nutria fur is inferior, nutria pelts are time-consuming to process and nutria are heavier to carry out of the marsh than muskrats. In addition, fur markets and the profits from nutria pelts have been subject to fluctuations due to a variety of factors such as the animal right's movement, fashion trends, U.S. exchange rates, and the political and economic trends in consumer nations (Maryland Department of Natural Resources 1997).

Nutria are a highly invasive species; there are confirmed reports of nutria from the Chesapeake Bay Bridge to Ocean City, Maryland and south to the Virginia border. Nutria are also on the western shore of Maryland in the Patuxent and Potomac Rivers, and to the northeast in Delaware.

Nutria control has been attempted at Tudor Farms, a 7,000-acre, privately-owned tract in Dorchester County. Despite an annual harvest of 4,000 to 5,000 nutria, the population appears to be unaffected. Population estimates range from 13,000 to 20,000 animals on this farm (Ras 1999), and nutria are continuing to degrade the marsh.

Other states, such as Louisiana, also are attempting to control nutria numbers. In 1938, 20 individual nutria were introduced in Louisiana and, by the 1950s, the nutria population exceeded 20 million animals (Nowak 1991). By 1962, nutria had replaced the native muskrat as the leading fur bearer in Louisiana (Lowery 1974). In 1998, Louisiana received approximately $2 million in federal assistance to control nutria. Staff from Louisiana and Maryland have discussed nutria control and management strategies. However, important biological information necessary to control nutria populations effectively is still lacking in both Louisiana and Maryland.

In 1994, the Maryland Department of Natural Resources invited a nutria expert, L. M. Gosling, to visit the Eastern Shore and assess the situation. Dr. Gosling, previously led a 10-year program that resulted in the successful elimination of nutria from Great Britain. He pointed out several weaknesses in the information base in Maryland, and recommended that Maryland immediately implement a pilot management program of intensive nutria control, compare trapping strategies, and learn more about nutria behavior in Maryland by using a combination of radio-telemetry and mark/recapture techniques. Twenty-three federal, state and private organizations joined forces, created the Nutria Control Partnership (Partnership), and developed a plan to address marsh loss and control of nutria in Maryland. The Partnership plan follows Dr. Gosling's recommendations, and includes activities to collect the information needed to control nutria in Maryland.

We (the Partnership) plan to mark nutria in all treatment and control areas to generate accurate population estimates, and to use radio-telemetry to obtain data on nutria movements, behavior and life history information. These data are essential in developing a successful statewide nutria eradication program. The Partnership recommends implementation of a management program to investigate nutria control, and to quantify the interactive effects of several factors on marsh loss.

We also suggest a three-year pilot program to provide the information needed to support a full-scale effort to eliminate nutria and restore the marsh ecosystems in Maryland and other affected states. The objectives of this pilot program are to:

1. establish an accurate estimate of nutria populations and animal densities in the three study areas;
2. ascertain the most efficacious trap types and trapping strategies (maximize capture/effort indices) to optimize intense harvest and achieve nutria population reduction;
3. evaluate the effects of intense population control on home range and movement patterns of nutria;
4. determine how intense population control affects nutria reproductive behavior and performance;
5. ascertain if the health of the nutria population is influenced by intense harvest;
6. monitor the effects of intense harvest to reduce nutria populations on vegetative response of native plant species;
7. develop management recommendations for use in eradicating nutria in Maryland and other affected states.

Study Areas

We propose using three study areas, which are representative of our partnership effort, for the pilot program. Each of the areas will have a treatment and a control area. The treatment areas will undergo intensive trapping/hunting of nutria, and control areas will not be subjected to intensive harvest. The three general areas and the size of the specific study sites are:

1. Blackwater National Wildlife Refuge, a federal area (2,500 acres);
2. Fishing Bay Wildlife Management Area, a state area (2,000 acres); and
3. Tudor Farms, a private area (3,800 acres).

Nutria Management

We propose using four trappers at each of the three treatment areas. The 12 trappers will be supervised by a field supervisor, who will report to an advisory team. The advisory team will provide advice and guidance for the pilot program, and assist in evaluating the overall success of the program. This advisory team will serve as an independent monitoring body to provide objective direction and guidance for the program. The advisory team will include representatives from the federal, state and private partners in this joint initiative.

Trapping will be conducted intensively, year-round, for three years during the pilot program. Several different trap types (cage, snare, foothold, conibear, drowning cage, floating platforms, and baited sites), trapping strategies and shooting will be compared. Trapping methods will be compared to determine trap efficacy, to maximize the number of nutria captured and to minimize capture of any non-target species. For example, perimeter trapping will be compared with saturation trapping in order to determine the most effective method. Progressive trapping will be used to cover the entire area under study. Capture/effort indices, video monitoring of baited sites, recovery of marked animals and other methods will be used to determine the thoroughness of nutria removal. We will collect data on the capture of non-target species to assess which trapping techniques minimize impacts on non-target animals. In addition, trappers will collect data on capture success by set and trap type, as well as on nutria captured (sex, age, weight, reproductive status, and if the animal was marked or unmarked).

We will monitor trapping success by looking at reduction of nutria as measured by catch per unit effort; estimates of abundance, trapping mortality rate, and the percentage of nutria removed through joint analyses of capture-recapture and telemetry data; and post-trapping presence of nutria through indices of field sign and video monitoring at baited sites.

Research

We plan to radio-collar 75 nutria in each of the three treatment areas (N=225), and 50 in the three control areas (N=150) for a total of 375 radio-collared animals. These animals will be tracked throughout the year to determine daily and seasonal movements, habitat use, behavior, reproductive habits, and responses to various levels of trapping pressure. In addition, we plan to mark 200 nutria (ear tags/toe tags) in each of the treatment areas and in each of the control areas, for a total of 1,200 marked animals. Using mark/recapture data, we will develop density estimates to compare the nutria populations in the treatment and control areas and to assess the impacts of the trapping efforts. In addition, we will develop estimates of abundance, survival and mortality to aid in measuring the success of the pilot program. We will compare and evaluate the effectiveness of a variety of trapping techniques and strategies in terms of reducing nutria populations in different habitats. We will analyze the impacts of different techniques on non-target species. The results of this research will provide useful information for the subsequent removal of nutria throughout Maryland and other areas in the United States where nutria have become established. In addition, we will compare the fecundity of nutria in the treatment and control areas using placental scars and carcass characteristics. Nutria may increase their reproductive activity in response to intensive trapping pressures, and we will analyze the differences between exploited and unexploited populations.

Public Education

We will develop public awareness programs to educate the public about the importance of controlling nutria and restoring wetlands within Maryland. We will use a variety of communication tools to increase the public's understanding of the impact nutria are having on Maryland's marshes and other affected areas in the United States. We will share this information with schools, media, interest groups, legislators, partner agencies, business groups, landowners, and the general public. Our communications tools and strategies include: holding public information meetings, developing an educational "tool kit" including question and answer sheets, fact sheets, news releases, articles for newsletters, news clippings reprinted with permission, maps and aerial photos of impacted areas, a video, brochure, advisory group membership list, and how to get involved tip sheet. In addition, we will post information on agency Internet sites; provide an interactive display at Blackwater National Wildlife Refuge; provide briefings for key audiences and stakeholders; host site visits at Blackwater; and develop press kits. By including study sites adjacent to the Wildlife Drive on

Blackwater, we can provide interpretative exhibits for the public to learn about the nutria control program and marsh restoration efforts. We plan to make extensive use of the visual educational opportunities and public outreach at Blackwater National Wildlife Refuge.

Wetland Restoration Demonstration Project

Nutria eradication is a vital component to minimize future damage to wetland vegetation and to prevent wetland loss. Preliminary findings of an ongoing study investigating plant responses to nutria herbivory suggest that aggressive actions are needed to restore wetlands severely damaged by nutria (M. Haramis personal communication: 1999). We propose a wetland restoration demonstration project as part of our pilot program. The goals of this demonstration project are to identify, develop and demonstrate methods to restore marsh.

Marsh loss along the Blackwater River has been the result of several factors including submergence (long-term increase in water levels due to land subsidence and sea level rise) (Stevenson and Kearney 1996). Nutria foraging has further exacerbated marsh loss under increased flooding stress because grazed plants are more likely to die when inundated (Baldwin and Mendelssohn 1998). They also exhibit poor germination and vegetative growth (Galinato and van der Valk 1986, Baldwin et al. 1996). These contributing factors are consistent with the pattern of marsh loss in Dorchester County; open marsh first appears as holes in contiguous marsh, then enlarge and persist (Stevenson et al. 1985).

Rising water levels are a primary threat to emergent vegetation in the Blackwater Basin. Restoration therefore must focus on methods to elevate the marsh. Two techniques of sediment augmentation are: (1) fill in or "grout" nutria swim canals and eat-out areas to raise the deteriorated marsh surface up to the vegetative surface of the marsh; and (2) raise the general elevation of the marsh surface using broad sediment application.

Researchers in Louisiana found that thin-layer deposition was effective in increasing elevation of the marsh surface, and promoting vegetative growth of cordgrass (*Spartina alterniflora*) in areas formerly too low to support growth (Ford et al. 1998). We suggest that thin-layering may be useful in restoring marsh in Dorchester County (Blackwater National Wildlife Refuge and Tudor Farms).

We propose a factorial arrangement of treatments in a split-plot design, with elevation and planting of wetland vegetation serving as the whole-plot effects, and herbivore grazing as the subplot effect. This factorial arrangement of treatments will allow us to quantify the interactions among various factors. For example, does adding sediment produce the same effect if nutria are present and the area has been planted in native vegetation.

Experimental areas will be randomly established at Blackwater and Tudor Farms in deteriorated marsh, in or near areas that contain some emergent vegetation. Each experimental area will receive all combinations of the following treatments, replicated five times:

Elevation:

1. no sediment applied;
2. 1 to 2 inches applied with thin layering; and
3. 3 to 4 inches applied with thin layering.

Planting:

1. no planting; and
2. planting with Olney's three-square bulrush (*Scripus americanus*).

Nutria Grazing:

1. unfenced (nutria have access); and
2. fenced to exclude nutria.

Growth, coverage and quantity of vegetation in each plot will be measured monthly during the growing season for three years. Measurements such as stem density, height, coverage, leaf area index, and standing biomass will be recorded. Environmental parameters such as salinity, soil redox potential and canopy light penetration will be monitored. This information will be directly applicable to designing large-scale wetland restoration projects in other wetland areas damaged by nutria.

In-kind Contributions from Partners

Removing nutria from the State of Maryland and restoring wetlands presents a major challenge. However, by working together cooperatively with state, federal and private partners, we will have a greater chance of meeting this challenge. The following agencies have offered to contribute in-kind services from their existing resources to support the pilot plan and help reduce the overall budget request for the nutria control program: U.S. Fish and Wildlife Service (Blackwater National Wildlife Refuge and the Chesapeake Bay Field Office); the U.S. Geological Survey, Biological Resources Division (Maryland Cooperative Fish and Wildlife Research Unit); University of Maryland—Eastern Shore; University of Maryland—College Park; Maryland Department of Natural Resources; Tudor Farms; and Ducks Unlimited.

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Invasive Species and the Conservation Community

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What Environmentalists Haven't Done

Before proceeding, we need to make one thing clear, we aren't faulting environmentalists for their insufficient engagement with invasive species. We and our fellow members of the Environmental Working Group on Invasive Species work in or are closely involved with the conservation community, and we know it wouldn't be fair to judge them too harshly for their shortcomings regarding invasives. For one thing, the conservation community is increasing their involvement with the issue, and we hope that our working group will accelerate and focus that involvement. We discuss these matters below. For another thing, significant obstacles stand between the conservation community and vigorous involvement, which is another subject we examine in this paper. We conclude by discussing some measures environmentalists may support as they rise to meet the challenge of invasive species.

Let's begin by thinking about lather leaf (*Colubrina asiatica*) in Everglades National Park. An invasive, vine-like shrub from tropical Asia, lather leaf is spreading rapidly through the park's coastal hammocks and mangrove swamps (D.T. Jones personal communication: 1997). This climbing invader shrouds and kills buttonwood, mangroves and other native vegetation (Doren et al. 1997).

Lather leaf constitutes a significant threat to an area of exceptional biological value; Everglades National Park is the only place in the Western Hemisphere to be named an International Biosphere Reserve, a World Heritage Site and a wetland of international importance. Yet, due to budget constraints, little is being done to combat lather leaf, although very recently a fair amount of money was procured for that process. (We should note that the National Park Service, as well as assorted other federal, state and local agencies, has committed considerable resources to battling invasives around the nation. Unfortunately, considerable isn't enough.) A lack of funding likewise prevented park managers from eradicating lather leaf when it first appeared, when a paltry $20,000 or so would have done the job (D.M. DeVries personal communication: 1997).

One would expect the conservation community to be in a lather over lather leaf. The health of the park is prominent on the agendas of numerous environmental groups, who are striving to improve its water pollution and water supply problems. Imagine the protests from conservationists if a corporation attempted to drill oil wells along the park's coast, yet lather leaf and its ilk pose a greater long-term danger than would oil wells. The conservation community has given some attention to melaleuca (*Melaleuca quinquenervia*), Australian pine (*Casuarina spp.*) and Brazilian pepper (*Schinus terebinthifolius*), the high-profile Everglades exotics, but even in these cases the amount of attention falls short of what the situation warrants.

The modest engagement by the conservation community regarding invaders of natural areas is not confined to Everglades National Park. Only a few environmentalists have expressed concern about efforts to bring raw logs from Siberia into the western United States, which might introduce the voracious Asian gypsy moth (*Lymantria dispar*) and other invasive insects and pathogens that could devastate vast expanses of western forests (Office of Technology Assessment 1993). Few conservation groups have pressed for the control of Chinese tallow (*Sapium sebiferum*), though this insidiously pretty tree is overrunning coastal prairies throughout the South (The Nature Conservancy 1996), including habitat vital to endangered species icons, such as the whooping crane (*Grus americana*). Nor have many environmentalists called for the control of the balsam wooly adelgid (*Adelges piceae*), an insect that has killed nearly every adult Fraser fir tree (*Abies fraseri*) in Great Smoky Mountains National Park (The Nature Conservancy 1996) the salt cedar (*Tamarix spp.*), a Eurasian tree that crowds riparian areas and monopolizes precious water throughout the desert Southwest (Office of Technology Assessment 1993); or the green crab (*Carcinus maenas*), which is disrupting native marine communities in many bays along the West Coast (The Nature Conservancy 1996).

As these examples suggest, a host of invasive exotic species plague natural areas all over the United States, yet in few cases is the conservation community deeply engaged. Many of these same species cause economic and social harm to farms, range lands, waterways, and urban areas, as well. These common problems present fertile opportunities to create productive partnerships. Conservationists have begun forming these crucial alliances with other people whose interests suffer from invasive species, but in this regard, too, they also have much work yet to do. Neither has the conservation community done enough to address the invasion at a broad, policy level, dealing with such areas as global trade and federal legislation.

What Environmentalists Have Done

Though the conservation community has not given invasive species the attention they merit, it has spent some time and resources on the issue. A number of small local and state organizations have devoted much of their modest capacities to the matter. For example, various native plant societies convey information regarding invasives to their members and to the press, encourage government and businesses to address the problem, and organize local removal and restoration efforts. People in several states formed exotic pest plant councils (EPPCs), which typically consist of individual scientists, land managers and conservationists who are concerned about alien plants. These EPPCs provide a clearinghouse for information regarding invasives and bring the issue to the attention of their organizations, policymakers and the media.

At the national level, a number of conservation organizations at least have the invasion on their radar screens. The most involved is the Nature Conservancy (TNC), one of the nation's largest conservation groups. TNC is unusual among such organizations in that it owns and manages large amounts of land. In fact, there are about 1,300 TNC preserves in the U.S. alone. TNC's interest in exotics has focused mainly on combating invasives in its preserves, and it has poured significant resources into on-the-ground remedies. TNC also has collaborated with private landowners, government agencies, the business community, and others in broad efforts, such as removing Brazilian pepper and planting native species in some of the Florida Keys and eradicating blue tilapia (*Orechromis aureus*) and restoring endangered Moapa dace (*Moapa coriacea*) in Nevada (Devine 1999).

Why has TNC paid so much attention to exotics? A visit to Garden Creek Ranch Preserve, which TNC partly owns and manages, provides the basic answer. This holding on the Idaho side of the Snake River is typical of TNC preserves; it's a place of high biodiversity and little development. However, yellow starthistle (*Centaurea solstitialis*) infests at least 2,000 acres (809 ha) in the preserve and Russian knapweed (*Centaurea repens*), common crupina (*Crupina vulgaris*), Canada thistle (*Cirsium arvense*), and numerous other weeds have established beachheads and are expanding (Devine 1998). Invaders are hard to ignore when every day you see the harm they cause. Given that many TNC lands have been invaded, the group had little choice but to deal with invasives. However, sources within TNC state that their organization realizes it must do more and is gearing up its anti-invasive efforts to better meet the scale of the problem (J.M. Randall personal communication: 2000).

The National Audubon Society owns and manages some preserves and, like TNC, has been battling invasives on its properties, but the other major national conservation groups don't own land and haven't been similarly compelled to confront invasive species. However, some of these large, landless organizations, such as Defenders of Wildlife, blend a consideration of invasive species into its other programs. For instance, in its biodiversity strategy for Oregon, Defenders highlights problems with invasive species in each ecoregion. Defenders' work on a major river basin restoration project has made invasives one of the ten main emphases of the initiative. And Defenders staffers serving on local and regional entities, such as watershed boards and parks commissions, have helped convince them to focus significant resources on exotics that threaten natural areas.

Many other examples exist. Conservationists have referred to invasives in lawsuits seeking endangered species status for sage grouse (M. Salvo personal communication: 1999) and in concerns about global trade. They've testified at Congressional hearings on biological control. Environmentalists have published booklets, magazine articles, and technical manuals regarding invasives. Nonetheless, given the magnitude of the alien invasion, the efforts of the conservation community have been insufficient and scattered.

Reasons Environmentalists Haven't Done More

One reason can be appreciated by anyone working in wildlife management; conservationists lack the resources to mount anti-invasive species campaigns painlessly. Most major environmental organizations have officers and staffers who would like to devote more time to invasive exotics, but these individuals already are working on water pollution, forests, wetlands, global climate change, and myriad other vital issues. They are reluctant to neglect any of their current responsibilities and they're reluctant to pile on more hours to their already overloaded work weeks in order to tackle invasives. In the end, conservation groups probably will have to shift some resources from other programs to invasive species, but we hope that significant additional funding can be found to help support invasive species work. In addition, the need to find new money can be minimized by blending awareness of invasive species into existing programs.

Just as the invasion is a relatively new issue for environmental groups, so is it relatively new to policy makers and the public. Even the scientific community, although it has known of invasives for many years, didn't extensively study the problems associated with invaders of natural areas until fairly recently. This short track record can hinder engagement. For example, some conservationists have expressed an interest in preventing the entry into the U.S. of new problem species, but as of yet no one has developed a simple method to accurately predict which species will become invasive. Without such a method, preventing the entry of new invasives is more complicated and diffused, which makes it difficult for the conservation community to rally its troops behind a prevention effort.

In addition, the public's lack of familiarity regarding exotics puts conservation organizations in something of a Catch-22—their members know little about invasives, so it is hard for the organizations to make exotics a high priority. But until they make exotics a high priority, their members aren't likely to know or care much about invasives.

Even when conservation organizations elect to take the initiative in educating their members, which many have begun doing, the nature of the invasive species problem complicates the learning process. It is easy to communicate the harm caused by a clearcut or an oil spill. A single dramatic photograph can stir concern, even action. People don't have quite the same response to a photo of a wetland lush with the lovely blossoms of purple loosestrife (*Lythrum salicaria*).

It is harder still to convince people that the health of the land dictates the control of mountain goats (*Oreamnos americanus*) in Olympic National Park or wild horses (*Equus caballus*) in the Great Basin. Even when the animals can be removed without killing them, many members of conservation groups and the public voice concern. When the elimination of invasive animals does involve killing them, that concern sometimes erupts into fierce protest.

The Nature Conservancy knows all too well how passionate such protests can become. Faced with the ravaging of some of their Hawaiian preserves by pigs, TNC reluctantly decided that, in 1989, in places where other methods wouldn't work, it would be necessary to snare and kill some of the pigs. Some animal rights groups objected to the snaring. People for the Ethical Treatment of Animals (PETA) was especially vehement. PETA picketed TNC headquarters, disrupted TNC meetings, sent inflammatory literature to TNC members and boycotted some of TNC's corporate sponsors, going so far as to chain themselves to the doors of Nature Company stores. TNC persevered and eventually both the pig population and PETA's protests diminished to background levels, but the Conservancy paid a high price in terms of bad publicity, personal misery and wasted staff time (Devine 1998).

Other conservation organizations also have experienced nasty confrontations with animal rights groups, and the fear of stirring up vocal animal advocates sometimes inhibits the anti-invasives efforts of the conservation community. And it is more than a public relations problem. Many conservationists have legitimate concerns that invasive animals may endure unnecessary pain and death in the course of control programs. Taking such concerns into account can complicate matters, even when people acknowledge the greater good of keeping the ecosystem healthy.

As with the control of alien animals, the use of chemical pesticides to fight invasives creates dissension within the ranks of environmentalists. Reducing pesticide pollution has long been one of the defining tenets of the environmental movement and it's a tough sell to make an exception in the case of invasive species. And most environmentalists feel that it should be a tough sell, that the use of pesticides on invasive organisms should receive close scrutiny. Many conservationists may resign themselves to occasional pesticide use as a lesser evil than an unchecked invasion, but even they worry, with good reason, that pesticides may be applied too freely and not only as a last resort. They also worry that some land managers might use chemicals as a crutch, postponing the need to make basic changes in the way some lands are used.

Animal control and pesticide use are two examples of a fundamental dilemma that the conservation community must work through as it comes to grips with the alien invasion. Many environmentalists distrust active management. They've seen excessive logging done in the name of forest health, ecologically ruinous fire suppression carried out to protect trophy homes and timber supplies, and the control of native predators in order to protect livestock. Specifically in the realm of invasive species, environmentalists often have seen active management go awry. They remember such fiascos as the introduction of Indian mongooses (*Herpestes auropunctatus*) on various islands in an ill-fated attempt to control rats; the planting of kudzu (*Pueraria lobata*)" a.k.a. "the vine that ate the South"—to curtail erosion; and the importation of opossum shrimp (*Mysis relicta*) into the Flathead River-Lake system in Glacier National Park to boost game fish populations, which started a ripple effect that decimated the whole community (Devine 1998).

Yet many invasive species can't be controlled without some active management. The conservation community's default position of "leave it alone" works well when trying to protect wild lands from logging, mining, grazing, urban sprawl, oil exploration, ski development, and the like. But a hands-off approach often is not sufficient to repel invasive species. Certainly it would help if people quit importing invasive species and curtailed management practices that make land vulnerable to invasion, but such measures alone would not be sufficient to stave off harmful exotics. For one thing, non-native species already have invaded a great many natural areas and invasives seldom go away on their own. But even many pristine wildernesses eventually will be invaded to some degree unless managers actively prevent invasion and carry out early detection and eradication programs. The conservation community sooner or later (and we hope sooner) will need to determine the appropriate role for active management of invasive species.

What Environmentalists Will Do in the Future

We don't know. But we do have some ideas and some hopes.

All three of us belong to the Environmental Working Group on Invasive Species (EWGIS), a new entity formed in November 1999, with a grant from the Turner Foundation. So far, we have members from American Lands Alliance, Defenders of Wildlife, Environmental Defense (formerly the Environmental Defense Fund), TNC, Sierra Club, Wilderness Society, and World Wildlife Fund, along with an executive director and an advisor from the Turner Endangered Species Fund. In addition, we'll be communicating with a wide network of scientists, land managers, industry representatives, private land owners, government officials, and conservationists whose groups aren't represented on EWGIS.

Our mission is to energize and focus the anti-invasion efforts of the conservation community in order to protect our nation's wild lands. We hope to perform some functions that have been largely neglected within the conservation community. For example, EWGIS will be a forum for multi-organization discussions on invasives and a clearinghouse for conservation-oriented information regarding non-native invaders. Perhaps most important, EWGIS can be the unifying force that brings environmental groups together to pursue anti-invasives initiatives. Concerted efforts by conservationists can exert a powerful influence on legislation, management plans, funding allocations, and the like. More generally, an informed and determined environmental community can fundamentally shape invasive species policy in the U.S. and, to some extent, in the world.

We also hope to help conservation organizations address invasive exotics in the context of their other programs. Many of our environmental problems and ineffective efforts to solve them exist because we look at things in isolation, not as dynamic ecosystems. We need to make sure that when people gather around a table to discuss a forest plan or a river corridor restoration or an endangered species study, they also consider invasives.

So much for sweeping, even grandiose, intentions. Though EWGIS is so new that we don't yet have our detailed goals nailed down, we can get a bit more specific about a few of the things we may urge an energized conservation community to accomplish. Whether a particular conservation organization signs on to any initiative EWGIS may promote is, of course, the prerogative of that organization. Following are some possibilities, listed in no particular order:

- Convey the conservation community's views to the framers of the National Invasive Species Management Plan—a document mandated by President Clinton's 1999 executive order on invasive species.
- Strive for a robust and ambitious National Plan, and work to see that the plan gets implemented, not shelved.
- Strengthen existing legislation regarding invasive species, such as the Federal Noxious Weed Act, and make it more attuned to the needs of natural areas.
- Propose or support new legislation regarding invasives, especially those that affect natural areas.
- Urge government, business and non-profits to substantially increase their spending on invasives, particularly regarding natural areas.
- Support the development of a nationwide early detection and eradication program; no more lather leafs.
- Improve screening for invasives at U.S. borders, and greatly increase screening for invaders of natural areas, which currently get little attention.
- Structure trade agreements so that legitimate concerns about invasive species are not construed as illegal trade barriers.
- Improve management practices that facilitate the spread of invasive species, such as overgrazing and dam operations that create river conditions in which exotic fish thrive and natives languish.
- Promote the use of native plants or non-invasive exotics by government agencies, developers, property owners and homeowners.
- Form and support partnerships with property owners, industry and all levels of government.

Some of the most important partnerships will be between conservation organizations and wildlife and natural resource agencies. Agency scientists and managers could provide environmentalists with vital information about invasives and strategies for dealing with them. In turn, a committed environmental community could greatly boost the anti-invasives programs of government agencies.

Let's imagine that lather leaf hadn't appeared in Everglades National Park yet, that it doesn't show up until 2010. By then park managers would be able to enlist the aid of environmentalists, perhaps via a decade-old, well-oiled anti-invasives machine called EWGIS. The conservation community could press the Administration and Congress for the necessary funding and perhaps even supply a corps of informed and dedicated volunteers to assist with lather leaf removal. Better yet, assuming that, by 2010, the alien invasion is established as a high priority among environmentalists and they've long been pressing government to address the problem, lather leaf wouldn't even have to be dealt with in such an ad hoc manner. The park service already would have the budget to eradicate lather leaf and any other serious pest that crops up. And maybe the vastly improved invasive species border patrol of 2010 would have prevented lather leaf from ever entering the U.S.

The conservation community and the nation's wildlife and natural resource agencies won't agree on every issue. No doubt there even will be times when environmentalists challenge agency practices. For example, once conservationists tune in to the invasion, they'll probably question agencies that stock exotic game fish in places where those invaders harm native fish. But in the large majority of cases, the conservation community and the agencies likely will be on the same side. Together we can protect a great deal of habitat and wildlife from invasive species.

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Session Five.
NEPA After Thirty Years: The Good, The Bad and The Ugly

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NEPA After Thirty Years: The Good, The Bad and The Ugly

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A landmark piece of legislation, the National Environmental Policy Act (NEPA), remains alive and well at the ripe old age of 30. President Nixon breathed life into a national mandate for a better and healthier environment when he signed this legislation into law on New Year's Day in 1970. NEPA's passage marked the beginning of a comprehensive national policy for integrating environmental considerations into the decision-making process of federal agency actions.

The NEPA process involves the preparation of a written document that provides enough information to ensure that a fully informed and well thought-out decision can be made. Meanwhile, all interested or affected parties are assured that environmental concerns are considered during this decision-making process. Specifically, the written document addresses environmental impacts, unavoidable adverse effects, alternative actions, short-term uses and long-term productivity, and any irreversible or irretrievable commitment of resources.

After the adoption of NEPA, no longer were decisions to be made behind closed doors. Now all interested or affected parties could review and comment on the proposed action. The "hard look" at these federal actions and their consequences occurs during the early planning stages of the project, not as an afterthought. Procedures are now in place to ensure that environmentally sound decisions can be made.

Thirty years of practice have borne out some positive and negative trends in NEPA implementation. In general, the number of lawsuits filed claiming a failure of the federal agency to prepare a NEPA document or, more commonly, an inadequate document have declined. So it seems, we are becoming better at analyzing and articulating our proposed actions. More thorough analyses during the planning stages of a proposed action have resulted in ways to minimize and sometimes completely avoid environmental impacts. This has allowed the documentation process to be satisfied often with the preparation of an Environmental Assessment (EA) instead of a full-blown Environmental Impact Statement (EIS). As a result, more EA's are being prepared today than EIS's, saving time and money. Federal agencies have also learned the importance of the scoping process with earlier and more broad-based input being sought.

Yet, meeting the full intent of NEPA continues to elude some practitioners and shortcomings can be identified. The scoping process continues to fall short in the eyes of some interested and affected parties. Complete integration of all pertinent federal and state laws remains a goal. The cumulative impacts of all these scrutinized federal actions are not being fully assessed. Tracking the effectiveness of NEPA in protecting the environment also is lacking. Although never quantified in the legislation, have the expected benefits to the environment been realized by avoiding the impacts? And what has the effectiveness of approved mitigation measures been?

So where are we after 30 years of NEPA? Have we spent the taxpayer's money wisely? Have we made a sound investment in our children's future? Have all of our collective efforts had a positive effect on the environment and human health? Is NEPA more than a costly and time consuming mandate?

Analyzing the Indirect and Cumulative Impacts of Federal Agency Permitting Actions and Approval Decisions: A Common Sense Approach to Improve the NEPA Process

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Thirty years after President Nixon signed the National Environmental Policy Act (NEPA)[1] into law, a myriad of judicial opinions and agency guidance have answered most questions concerning implementation of the statute. The Council on Environmental Quality (CEQ) has put flesh on the bones of the statute through its regulations and various guidance documents that instruct federal agencies how to fulfill the congressional mandate to consider the impacts to the human environment of all proposals for major federal action.[2] Generally speaking, federal agencies prepare adequate environmental impact statements and environmental assessments with regard to the "direct" impacts of a proposed action. Unless an environmental impact statement (EIS) sweeps significant issues under the rug or ignores them altogether, reviewing courts usually find that the agency has taken the requisite "hard look" at the expected immediate environmental impacts of a proposed action.[3]

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[1] *42 U.S.C. § § 4321,* et seq.

[2] See *40 C.F.R. § 1500. Each federal agency also has been required to promulgate regulations governing itsown NEPA compliance. For a summary of the NEPA regulations for most federal agencies,* see *Mandelker,* NEPA Law and Litigation, *§ 2.07 at 2-18 – 2-23. The CEQ and EPA also maintain a link to agency NEPA regulations on their web sites.* See **http:/ceq.eh.doe.gov/nepa/nepanet.htm; http://www.epa.gov/oeca/ofa/nepaweb.html.**

[3] *As discussed below, the "hard look" doctrine can be interpreted in a variety of ways. Despite these variations, the doctrine is generally accepted and applied in most NEPA cases. In one of the earliest decisions to apply this standard,* Maryland-National Capital Park & Planning Comm'n v. U.S. Postal Service, *487 F.2d 1029, 1040 (D.C. Cir. 1973), the court asked, "did the agency take a 'hard look' at the problem, as opposed to bald conclusions, unaided by preliminary investigation?"*

Despite the general perception that NEPA compliance has become more routine, the identification and evaluation of "cumulative" and "indirect" impacts of proposed actions continues to vex agencies across the federal government. These issues become even more sensitive when private parties find themselves involved in the NEPA process as a result of federal permitting decisions or other authorization for private action on or adjacent to federal lands. Private parties often wonder why the impacts of completely unrelated projects or other temporally or geographically distant actions figure prominently in the evaluation of *their* project. The CEQ recently concluded that: "Federal agencies have struggled with preparing cumulative effects analyses since CEQ issued its regulations in 1978. They continue to find themselves in costly and time-consuming administrative proceedings and litigation over the proper scope of the analysis. Court cases throughout the years have affirmed CEQ's requirement to assess cumulative effects of projects but have added little in the way of guidance and direction. To date, there has not been a single, universally accepted conceptual approach, nor even general principles accepted by all scientists and managers."[4] As awareness of suburban sprawl and related issues increases, federal agencies will be under great political pressure to improve and intensify the review of the indirect or cumulative impacts of a proposed action.[5] Indeed, federal approval of permits for private development, resource recovery or road construction may pose relatively insignificant direct impacts, but intense growth-inducing or cumulative impacts.

This paper will focus on the current process by which agencies evaluate the indirect and cumulative impacts of federal actions, with an emphasis on permitting or approval decisions for private development. We first summarize CEQ's regulatory framework for the consideration of indirect and cumulative impacts and the goals of a successful review of those impacts. We then explore

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[4] *See "Considering Cumulative Effects Under the National Environmental Policy Act," Council on Environmental Quality, January 1997 at 4.*

[5] *Recently, some commentators have suggested that NEPA may be the appropriate vehicle to promote the "smart growth" movement. There have already been calls to use NEPA as an important tool in the analysis of the problem of sprawl.* See *Ward, Brown and Lieb, "National Incentives for Smart Growth Communities," 13 Summer Natural Resources and Environment 325 (1998) at 329 ("NEPA provides a potentially powerful tool for assessing the environmental impacts of, and potential alternatives to, major federal actions that contribute to sprawl. These federal actions include relocation of federal facilities from urban areas to ex-urban locations, and federal leasing, infrastructure funding and construction activity.").*

the difficulty in meeting the "hard look" standard by examining courts' inconsistent application of that doctrine with regard to cumulative or indirect effects. Next, we attempt to identify the challenges currently facing federal agencies in their efforts to consider these impacts through the presentation of several "real-life" scenarios. Finally, we propose several common sense solutions that could lead to a more useful and meaningful evaluation of cumulative effects and, therefore, greater predictability for private party proponents involved in the NEPA process.

Regulatory Background

The CEQ regulations set forth definitions of the various categories of impacts or effects that should be analyzed in an impact statement or environmental assessment.[6] The "direct effects" of an action are "caused by the action and occur at the same time and place" (40 C.F.R. § 1508.8[a]). "Indirect effects" also are "caused by the action," but are categorized as those effects that "are later in time or farther removed in distance but are still reasonably foreseeable" (40 C.F.R. § 1508.8[b]). Finally, CEQ defines "cumulative effects" as "the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 C.F.R. § 1508.7).

In theory, these definitions distinguish the wide range of effects usually associated with any proposal and assist the public and agency decision maker's comprehension of the NEPA analysis. For example, in reviewing an agency's evaluation of impacts of proposed mining activity on public land, an interested member of the public should normally expect to find analysis of air, water and wildlife resources impacts from development of the mine itself (direct), the associated effects from the growth of a nearby town to provide shelter and services for the expected increase in mining employees (indirect or secondary), and the incremental effects of the proposed mine when viewed in conjunction with other past, present or reasonably foreseeable uses of public lands in the vicinity of the mine (cumulative).

However, as with any broad definitions, confusion often arises when categorization of expected impacts is not so easily accomplished. For example, both the definitions of "direct" and "indirect" effects include a causation re-

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[6] *The terms "effects" and "impacts" are used interchangeably in the CEQ regulations.* See *40 C.F.R. § 1508.8(b).*

quirement. In many instances, there is legitimate disagreement whether a private development (a shopping mall, a planned community) "causes" certain growth-inducing or secondary effects. If an agency rejects a growth-inducing theory, can it reasonably restrict analysis of indirect effects?[7] Similarly, because "cumulative" effects have been defined as the "incremental impact" of a proposed action, should an agency analyze those impacts in detail if that impact is insignificant or unrelated to the resource impacts expected from the past, present or reasonably foreseeable action identified by the agency? Unfortunately, some courts have added to the confusion by attempting to further parse the general CEQ definitions.[8]

As will be discussed in further detail below, agencies tend to create trouble for themselves by adhering to formulaic or strict categorization of expected impacts. One thing is certain – an agency must consider all three types of effects and provide the public and the ultimate decisionmaker evidence in the NEPA document itself and/or the administrative record which supports its rationale for its conclusions. Long before CEQ promulgated its widely accepted NEPA regulations, it indicated that "[b]oth primary and secondary significant consequences for the environment should be included in the analysis. For example, the implications, if any, of the action for population distribution or concentration should be estimated and an assessment made of the effect of any possible change in population patterns upon the resource base, including land use, water and public services, of the area in question" (CEQ Guidance, 36 Fed. Reg. 7724, 7725 [1971]).

In its 1997 handbook on the consideration of cumulative impacts, the CEQ provided an excellent summary on the importance of a searching analysis of potential cumulative effects. An effective analysis, CEQ suggested, gives an accurate view of a proposed action, which by itself may have insignificant effects, but when considered in context with other past, present or reasonably foreseeable actions, would require mitigation measures or dictate that impacts

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[7] *Recent comprehensive studies of road improvement projects in the Washington, D.C. area, for example, have raised serious questions about the tendency of those projects to induce additional traffic. For most impact statements dealing with road improvements, the assumption has been that the project is designed solely to address existing or reasonably predictable demand.* See, *"More Lanes Better? Not Necessarily,"* Washington Post, *January 13, 2000 at B1.*

[8] See, e.g., *C.A.R.E. Now, Inc. v. Federal Aviation Administration, 844 F.2d 1569, 1574 (11th Cir. 1988) (interpreting the CEQ's definitions to find that cumulative impacts can be both direct and indirect).*

are truly significant ("Considering Cumulative Effects" at 7-10). CEQ's regulations specifically caution that agencies should consider whether "the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts" (40 C.F.R. § 1508.27[7]).[9] Consideration of other reasonably foreseeable projects also encourages coordination with sister agencies as well as a candid assessment of why the agency has selected a certain geographic or administrative area for evaluation.

When Has an Agency Taken a "Hard Look" at Cumulative and Indirect Effects?

One of NEPA's hallmarks is the fact-specific and case-by-case nature of the process. Each project must be evaluated on its own merits and the anticipated environmental impacts analyzed independently, even if the agency has addressed repeatedly similar projects and similar issues. Moreover, the level of detail that an agency provides in an impact statement and the scope of the analysis it chooses to address the wide range of resource impacts may vary dramatically depending on the proposed action. Such a process was anticipated by CEQ when it suggested in its introductory sections to its regulations that "[m]ost important, NEPA documents must concentrate on the issues that are truly significant to the action in question, rather than amassing needless detail" (40 C.F.R. § 1500.1[b]). Similarly, in discussing the implementation of the regulations, CEQ stated that "[i]mpacts shall be discussed in proportion to their significance. There shall be only brief discussion of other than significant issues" (40 C.F.R. § 1502.2[b]).

Unfortunately for lead agencies, this inherently reasonable policy creates a situation in which the proverbial "hard look" can and does vary from project to project. If an agency evaluates each proposed action independently, even with similar proposals one category of effects might be viewed as insignificant in one case and as significant in another. The agency and a reviewing court

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[9] See, Sierra Club v. Penfold, *664 F. Supp. 1303 (D. Alaska),* aff'd, *857 F.2d 1307 (9th Cir. 1988) ("if ever there was a paradigm instance of 'cumulative' or 'synergistic' impacts, it is this case"; finding that EIS must be prepared to analyze "dozens of small operations of a single type [that] incrementally contribute to deterioration of water quality in a common drainage stream.").*

might therefore expect a very different scope of review and level of detail in each case. This case-by-case approach is especially frustrating for private parties who expect some measure of predictability in getting a project completed. Their activities often depend on the completion of the NEPA process and, in many instances, cannot begin until litigation brought by interested citizens or opposing business interests is successfully defended. We assure our clients that the standard of review is extremely favorable to the agency (and by extension, our client), but we cannot predict ahead of time what aspect of the project will trigger intensive review or if perceived inadequacies in one narrow area of the analysis will trigger a remand and further delay the project.

Satisfying the "hard look" standard is most challenging when an agency considers a project's cumulative and indirect impacts. Not only have the courts failed to establish generally accepted methodology for the evaluation of these effects, but those few cases that have ventured into this murky field create vague guidelines that leave agencies open to criticism from many angles. Nowhere is this problem better illustrated than in the Ninth Circuit where two recent cases that focused on an agency's cumulative impacts analysis led to two starkly different results.

Various environmental groups and an Indian tribe successfully challenged the adequacy of an EIS that evaluated a proposed land exchange between the Forest Service and the Weyerhaeser Company in *Muckleshoot Indian Tribe v. U.S. Forest Service*, 177 F.3d 800, (9th Cir. 1999). Plaintiffs argued, in part, that the Forest Service failed to adequately identify and analyze the cumulative impacts of the proposed action. In rejecting the agency's analysis, the court held that an "EIS must analyze the combined effects of the actions in sufficient detail to be 'useful to the decisionmaker in deciding whether, or how, to alter the program to lessen cumulative impacts.' Detail is therefore required in describing the cumulative effects of a proposed action with other proposed actions" (*Id.* at 810 [citation omitted]). The agency was left with little guidance on how it could have rectified its errors. Precisely what level of detail would be deemed sufficient?[10]

Only six months after it issued the *Muckleshoot* decision, the Ninth Circuit disposed of a challenge to a cumulative impacts analysis fairly summarily.

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[10] *Subsequent to* Muckleshoot *a lower court in the Ninth Circuit tried its hand in providing some additional instructions regarding the level of detail expected in a cumulative effects analysis. In* City of South Pasadena v. Slater*, 56 F. Supp.2d. 1106, 1134 (C.D. Cal. 1999), the court held that when reviewing analysis of cumulative impact information, reliance on "very broad and general statements devoid of specific reasoned conclusions" is improper.*

In *Friends of the Bitterroot, Inc. v. U.S. Dept. of Transp.*, 1999 WL 1079851 (9th Cir. Nov. 30, 1999), the court reviewed an EIS that identified a number of "Known Related Projects" to a proposed highway expansion and assessed very briefly the probable cumulative impacts of those projects. The EIS concluded that "cumulative impacts are not expected" and offered a brief explanation for that conclusion (*Id.* at *1). Specifically, the EIS concluded that the cumulative effects associated with the related projects "may be in regard to access and densification of development," but that traffic would not likely increase as a result of related highway improvements. The majority concluded that "[t]he discussion may be summary, but it is sufficient" (*Id.*)

In a stinging dissent, Judge McKeown argued that the agency had not engaged in "meaningful analysis" of the cumulative impacts of the proposed action. "A mere listing without discussion of the underlying environmental data is insufficient" (*Id.* at *2, citing, *Sporting Congress v. Thomas*, 137 F.3d 1146, 1150 [9th Cir. 1998]). The dissenting judge concluded, based on the same record upheld by two of his colleagues, that "[t]here is no analysis to be found, much less any discussion of or reference to the data underlying these conclusions" (*Id*).[11]

The Ninth Circuit might have been well served to heed the advice of an earlier NEPA decision that perhaps set forth, in the most understandable fashion of any other published opinion, how an agency should approach the consideration of cumulative impacts. In *Fritiofson v. Alexander*, 772 F.2d 1225 (5th Cir. 1985), the court articulated the parameters of an effective (and defensible) cumulative effects analysis. The court suggested that an agency consider: "the area in which effects of the proposed project will be felt; the impacts that are expected in that area from the proposed project; other actions—past, proposed and reasonably foreseeable—that have had or are expected to have impacts in

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[11] *The Muckleshoot decision also turned on the agency's decision that another proposed land exchange was too speculative to include in the cumulative effects analysis. The court found that the agency could have reasonably concluded before the Final EIS was published that the other land exchange was likely to be consummated. Id. at 812. Again, the question of whether an unrelated project is too speculative to include in an EIS is a fact-specific finding that will vary depending on a court's interpretation of "speculative."* See, e.g., *Coalition for Canyon Preservation v. Bowers, 632 F.2d 774 (9th Cir. 1980) (no need to consider impacts of speculative road improvement projects); Walsh v. U.S. Army Corps of Engineers, 757 F. Supp. 781 (W.D. Tex. 1990) (agency did not have to consider cumulative impacts of merely contemplated actions).*

the same area; the impacts or expected impacts from these other actions; and the overall impact that can be expected if the individual impacts are allowed to accumulate" (*Id.* at 1245).

This checklist emphasizes the importance of defining the context in which cumulative impacts are evaluated. Before an overly broad and, perhaps, not very useful analysis is made, the agency should decide where it is looking, what projects matter and the expected impacts that are of greatest concern. Then, and only then, can the agency successfully consider the incremental impacts of the proposed action. The court in *Fritiofson* also provided a helpful suggestion regarding the intensity or level of analysis of the other related actions identified in the NEPA process. "We certainly do not mean to suggest that the consideration of cumulative impacts at the threshold stage will necessarily involve extensive study or analysis of impacts of other actions . . . .The extent of the analysis will necessarily depend on the scope of the area in which the impacts from the proposed action will be felt and the extent of other activity in that area" (*Id.* at 1246).

Even if an agency applies this more practical standard as a roadmap to undertake a cumulative impacts analysis, many questions remain. Courts have provided very little guidance on the sort of detail or methodology necessary to support an indirect or cumulative effects review. For instance, should the agency engage in traffic modeling to assess cumulative impacts on a proposed private development in an urban setting as it may have done to assess the direct impacts of construction of the new facility? Would some sort of qualitative analysis suffice or must the agency provide some data to support its review? The dissenting opinion in *Friends of the Bitterroot* and, to a lesser extent, the *Muckleshoot* decision, seem to mandate that an agency create some objective data in order to meet the standard of providing "useful" information in "sufficient detail" to the decisionmaker. Yet, requiring that level of detail may be overkill in many cases and only lead to further delay. Moreover, the data that is created may be imprecise at best.

Developing objective data to evaluate indirect or secondary impacts often proves even more confounding to federal agencies and private party proponents. While it is beyond dispute that certain projects carry with them the potential for ancillary or other spin-off development, many developers view the evaluation of secondary effects as an exercise in speculation and conjecture. A private party most likely has considered the full spectrum of impacts expected from its own proposal, but has not paid a great deal of attention to what other developers may or may not do in the future once the proposed project is completed. Even if the threshold question of whether the proposed project will actually cause other development is answered in the affirmative, the analysis of those impacts is often described in very general terms.[12]

Case Studies and Demonstrating the Challenges in Defining the Proper Scope of Review of Cumulative and Indirect Effects

Counseling private project proponents in the midst of a lengthy NEPA review creates nettlesome challenges, especially since they do not control the administrative process. Even if your client cooperates fully with the agency and the EIS consultant, it does not (and should not) make fundamental decisions about the document's scope of review.[13] Moreover, the project proponent often finds itself pitted against parties that advocate a broader analytic scope. These parties lobby aggressively for the agency to evaluate the cumulative or indirect effects encompassed in a larger geographic or administrative area and to include a greater number of future, and perhaps more speculative proposals. The following case studies demonstrate how defining the appropriate scope of review for cumulative and indirect effects often becomes the most divisive issue in the NEPA process.[14]

- A housing developer requires an individual Army Corps permit for the proposed filling of three quarters of an acre of wetlands as part of the construction of a master-planned community. The development can proceed without the proposed fill, but construction would be far more efficient if the private applicant can build a temporary bridge to avoid a natural stream on the property. Project opponents claim that the Corps should have prepared an EIS instead of merely an EA because the indirect effects of the housing development will create significant impacts on the

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[12] Several courts have rejected an agency's NEPA analysis for the failure to adequately address those impacts. See, e.g., Conserv. Law Foun. of New England v. General Services Admin., 707 F.2d 626 (1st Cir. 1983) (agency's analysis of secondary impacts of proposed lease or sale of property formerly used as naval installations); City of Rochester v. U.S. Postal Service, 541 F.2d 967 (2d Cir. 1976) (agency failed to consider secondary impacts of construction of new mail facility, such as abandonment of old facility and transfer of employees); City of Davis v. Coleman, 521 F.2d 661, 675 (9th Cir. 1975) (failure to analyze growth-inducing effects of construction of highway interchange).

[13] Any private party embroiled in the NEPA process is well advised to be a frequent contributor to the public comment process during scoping and when the Draft and Final EIS is published. The project proponent can best protect its interests by creating a favorable record prior to litigation.

[14] Some of the facts have been altered slightly to protect clients involved in pending litigation.

human environment. In fact, the opponents' comments focus solely on the proposed development.

- A state requests permission from the Federal Highway Administration to modify an existing ramp off an interstate highway. The request stems from a private party's desire to build a proposed entertainment complex that would plainly benefit from better access from the major highway. Opponents to the private development demand that the agency's EIS explore in detail the potential impacts and induced growth stemming from the entertainment complex.
- A mining company proposes to build a new transmission line along an existing federal easement to bring additional electricity to an existing mine. Although the company could obtain additional power from a number of sources, including building a plant on-site, the transmission line will be most economical and, because it will be built along previously disturbed public land, will have fewer environmental impacts than other alternative sources. Opponents argue that the EA consider in detail the impacts from future mining.
- A private developer intends to build a new mixed-use office and residential complex in a large, urban center. The proposal, supported by federal grants, will likely encourage (and the city elders are banking on this) ancillary development in the vicinity of the project. A competing developer recruits a citizen near the proposed project to challenge the EIS on the grounds that neither the indirect impacts of the proposal nor the traffic impacts associated with several ongoing improvement projects around town have been adequately addressed.

Besides the overarching problem of not having generally accepted methodology for evaluating cumulative and indirect impacts, these cases raise several additional issues.

First, acceding to the desired broader scope of analysis for most of these projects tends to place disproportionate attention on potential effects that are not directly associated with the proposed federal action. In order to conduct a detailed cumulative effects assessment of the proposed development that seeks the modest wetlands permit in the first example, the NEPA process easily could be prolonged for months. And, it would seem nearly impossible to avoid preparation of a full EIS once the impacts of the development are factored into the agency's significance determination.

Second, as the example of the proposed off-ramp demonstrates, expanding the scope of the federal NEPA document has the potential of usurping or, at a minimum, duplicating local zoning and/or environmental review. There can be little doubt that the private development benefits directly from the proposed highway improvement. Does that relationship, however, dictate an expansive focus on the private development in an impact statement? NEPA instructs agencies to analyze the impacts of major *federal* actions. The proposed entertainment complex clearly is not a federal matter. Moreover, state and local agencies usually conduct fairly extensive zoning and land use reviews that cover many of the resource impacts that normally would be evaluated in an EIS, albeit with a more limited focus.

Third, the causation element of CEQ's definition of indirect effects is highly subjective. The proposed transmission line in the third example clearly promotes mining operations. Yet, if the mining company can get power from other sources, the mine itself should not qualify as a secondary impact of the proposed use of federal land. Assuming that the agency properly evaluates effects associated with future mining in the context of cumulative impacts, should the agency commission time-consuming and expensive studies on various resource impacts that address solely mining operations?

Fourth, there is a great threat of duplicative analysis from other past, pending or future federal actions. Since the evaluation of cumulative impacts focuses on the incremental impact of the proposed action and not on the other actions identified as having potential cumulative impact themselves, the agency must integrate previous environmental assessments or impacts statements into the current NEPA process. In the last example, the traffic projects identified by the agency most likely have been studied in multiple EISs and supplemental EISs. An agency may encounter difficulty defending its conclusions with regard to the proposed action if it does not adopt or recreate much of the completed analysis. And, does the manner in which resource impacts were studied in other NEPA documents set a benchmark for the analysis in the current project?

Fifth, a private party often suffers from what we'll call the "sibling rivalry" syndrome. All too often, a parent misses the outbreak of a spat between her children and only witnesses the last push or the last shove. The sibling who strikes last gets punished, while the other, wearing a Cheshire Cat-like grin, walks away unscathed. The company applying for an individual wetlands permit, for example, may coincidentally be the fourth in a sequence of permits evaluated by the Corps in a particular area. While the proposed permit seeks permission to fill only a modest amount of low-quality wetlands, the previous three permits granted in the area have affected much more sensitive land and generated a great deal more controversy. Opponents seek to block the issuance of the last in the series of permits by attacking the agency's cumulative impacts analysis. Lost in this very political shuffle is the fact that the other siblings struck first and that the current proposal will not add incrementally to the impacts already discussed by the agency in other NEPA documents. Delay, often measured in years, leads to frustration of the private party's goals and abandonment of the project.

In describing these examples and problems, we do not mean to suggest that it is never appropriate to prepare a detailed cumulative or indirect impacts analysis. Quite to the contrary, the potential cumulative or indirect effects of a project may deserve the agency's most careful attention and may require the preparation of quantitative data to describe expected impacts. Due to the uncertainty surrounding the consideration of cumulative or indirect effects and the difficulty in articulating what are inherently speculative effects, however, our experience has been that the agency prepares a perfunctory analysis and paints its conclusions with a very broad brush. Consequently, the agency leaves itself vulnerable to the opponents to the proposed federal action and the associated private development in a future administrative challenge or federal litigation. How can an agency create a legally defensible cumulative or indirect effects analysis without having to prepare an encyclopedic EIS in every instance?

Solutions to the Problem: NEPA Is Not a Statute of Perfect

Dr. Bob Rotella, the famed sports psychologist, wrote a national bestseller called *Golf Is Not A Game of Perfect*. His theory, proved often by one of the authors of this paper, is that golfers struggle unnecessarily with their beloved hobby because they search in vain for the perfect swing, the perfect ball flight or the perfect putting stroke rather than focusing on the goal of the game – getting the ball in the cup. Although it may be somewhat of a stretch to compare NEPA to golf, many agencies also find themselves lost in the search for the perfect EIS, including a perfect cumulative impacts analysis, rather than concentrating on NEPA's ultimate goal—making an informed and better decision about a proposed action. Similarly, some courts, while professing to adhere to the "hard look" standard, find fault with agencies that have not carried out a cumulative or indirect effects analysis to an undefined level of detail. The CEQ recognized this problem when it cautioned: "The continuing challenge of cumulative effects analysis is to focus on important cumulative issues, recognizing that a better decision, rather than a perfect cumulative effects analysis, is the goal of NEPA and environmental impact assessment professionals."

Based on our view of the NEPA process from both the agency's perspective and that of the private party proponent, we offer these common sense approaches that may keep all parties focused on the goal of a better and more informed agency decision.

Use the Scoping Process Effectively

We cannot stress enough the importance of the scoping process. The agency should use this process to engage the public and other state and federal agencies in the identification of other actions, both public and private, that are within the general geographic area, that will be conducted in a similar time frame, and that may impact the same resources affected by the proposed action. All too often, an agency identifies completely potential resource impacts but leaves the cumulative and indirect effects to the end of the EIS process. It is no accident that the cumulative effects discussion often appears at the end of the impacts analysis, as almost an afterthought. Only by conducting a thorough scoping analysis can the agency avoid the problem of having to analyze after-the-fact the potential synergistic effects of certain actions when they are not taken into account in initial modeling or analysis.

Agencies also must explain and justify the limitations that they have established to define cumulative actions. In many cases, we find that the agency has a perfectly legitimate rationale for how and why it created criteria for the analysis of cumulative effects, but it does not explain that rationale until it appears in federal court answering a motion for injunctive relief. It is crucial to explain cogently in the administrative record the basis for determining the universe of cumulative actions that have been considered.[15] This explanation is especially crucial if an agency limits its review of indirect effects as a result of a determination that the proposed action will not *cause* certain impacts. That justification need not be elaborate, but it must be apparent.

Concentrate on the Significant Impacts, Not the Categorization of Impacts

Next, all parties involved in the EIS process should be less worried about categorizing certain resource impacts as indirect or cumulative and should be more concerned with the nature of the proposed action and the affected resources. To that end, NEPA documents should not address each resource impact with a separate section on direct, indirect and cumulative effects. The agency should assess where the most serious impacts will be experienced and determine the appropriate level of detail based on that analysis. By addressing most significant impacts with the greatest level of detail, it matters little whether the effects are labeled direct, cumulative or indirect.

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[15] *The CEQ suggests that cumulative impacts analyses can be defined properly by considering several factors: (1) time – how far into the future should an agency look; (2) geography – are there natural boundaries such as a river or a watershed; and (3) administrative limits – the boundaries of a national park or a forest district. "Considering Cumulative Effects" at 11-20.*

Accept that Assumptions Must be Made in the NEPA Process

Finally, agencies should not apologize for the fact that a cumulative or indirect effects analysis is, by definition, fraught with many assumptions and uncertainties. For example, is a particular project "reasonably foreseeable?"; how will certain actions impact adjacent land owners?; what other development may result if the proposed action is approved? Parties may disagree with those assumptions, but as long as they are explained in the EIS and the administrative record, the public has been provided the information necessary to participate intelligently in the NEPA process. Most important, the agency has been armed with all the information necessary to make a reasoned decision.

Conclusion

While the first 30 years of NEPA may have been marked by the search for an efficient and useful process for the consideration of environmental impacts, the next 30 years may very well focus on arriving at a generally acceptable methodology to define the appropriate scope of environmental review and how (or whether) federal impact statements can be integrated into general land use and planning decisions. All parties involved in the NEPA process should remember that no EIS is perfect and that reasonable people may differ on whether the assessment of cumulative or indirect effects captures precisely the impacts of the proposed federal action. For now, if an agency incorporates the evaluation of cumulative and indirect effects early in the NEPA process and explains its assumptions and ultimate conclusions, it would honor both the spirit and letter of NEPA.

Process Improvement: A New Focus for NEPA Programs in the Department of Defense

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In order to evaluate the effects of the National Environmental Policy Act (NEPA) after some 25 years of implementation, the President's Council on Environmental Quality (CEQ) commissioned a study to establish the legacy of NEPA to date.[1] This introspective is extensive—drawing from a full range of NEPA stakeholders and recognizing both the accomplishments and the failures of NEPA implementation (complete with examples of both). While more details are available in the publication, the conclusions are currently relevant to all federal agencies. In short, NEPA costs too much, takes too long and is often too late to affect the decision-making process; however, NEPA is not going away because it provides a mechanism to ensure stakeholder involvement in federal decision making. This study gave rise to a subsequent CEQ call for federal agencies to increase both the effectiveness and efficiency of the agency-level NEPA process, acknowledging shortcomings with regard to agency implementation. The Department of Defense (DoD) can draw upon these observations and conclusions to improve its NEPA program—in hopes of reducing costs, speeding the process and making the process more useful.

The CEQ study provides many insights into the NEPA process. The 25[th] anniversary effectiveness study evaluated NEPA in terms of strategic planning, public information and input, interagency coordination, interdisciplinary place-based approach to decision making, and science-based, flexible management approaches. With regard to strategic planning, the study concluded that the NEPA process is often triggered too late to be fully effective, although, when used as intended it can be a helpful tool. Regarding public information and input, the study concluded that NEPA provides an excellent opportunity for public input in the federal process; however, success is varied and depends upon the extent of agency outreach efforts. According to the study, NEPA interagency coordination when utilized has helped to avoid or resolve conflicts and reduce duplication of effort. However, such coordination is often difficult to achieve due to different agency timetables, requirements and modes of public participation. The use of interagency agreements has proven helpful. Integrated decision making provides better decisions that meet the needs of varied stakeholders.

The study found that "obtaining adequate environmental data and finding the tools to use it" (such as GIS) are key to an interdisciplinary approach.[1] The use of science-based, flexible management approaches involves the use of experience—through monitoring actual impacts—to guide effectiveness and predict impacts. The study found that this approach has been used by several agencies to reduce costs and improve environmental protection. The CEQ study concluded that NEPA could be improved with regard to effectiveness and efficiency in all the areas studied.

The Army Environmental Policy Institute (AEPI), partnering with Ballistic Missile Defense Organization (BMDO), the Office of the Deputy Undersecretary of Defense for Environmental Security (ODUSD-ES) and service NEPA practitioners, has framed and focused an approach to improve the NEPA process. As a backdrop to this effort, the AEPI staff was involved in the drafting of the CEQ effectiveness study and the Army's new draft NEPA implementation regulation, AR 200-2 "Environmental Analysis of Army Actions." These efforts led to considerable research into the underpinnings and intent of NEPA, as well as its history before and after passage.[2] An additional effort—a partnership with the International Association for Impact Assessment (IAIA)—addressed the state of NEPA tools and emerging opportunities.[3] Even the most knowledgeable practitioner will find some enlightenment in both of these references. Also, the content could be used to better frame and improve future NEPA practice and require change in order to improve efficiency and effectiveness.

Most NEPA practitioners do not dispute the general CEQ conclusions and observations about the state of NEPA. As implemented, the NEPA process is often post-decisional, and the cost and the time required for NEPA analyses and documentation is considerable. Conversely, most practitioners can recall delays in critical actions as a result of NEPA, and sometimes actions were either dropped from consideration or altered to produce a better project. Recognizing that 25 years of experience had created a potentially useful body of knowledge (a knowledge base), DoD hosted an online symposium, through the Defense Environmental Information Exchange (DENIX), to encourage discussion among DoD NEPA practitioners and to formulate ideas for possible process improvement. This site is accessible at *www.denix.osd.mil/denix/DOD/News/OSD/NEPA/forum.html* The site was commissioned by ODUSD-ES military departments and the BMDO to encourage collaboration and the exchange of ideas among DoD NEPA practitioners.

In order to spur discussion, this online symposium was "seeded" with the following topics (selected by service and OSD representatives):

1. appropriate NEPA documentation approval authority;
2. value and use of programmatic documents and tiering;
3. differentiation between Environmental Assessments (EAs) and Environmental Impact Assessments (EISs);
4. overall management of the NEPA process (including cost and mitigation tracking);
5. collaboration in the NEPA process;
6. connected actions and cumulative effects analysis;
7. public involvement;
8. integration of Environmental Justice (EJ);
9. administrative record;
10. alternatives;
11. mitigation;
12. base realignment and closure (BRAC); and
13. NEPA and Indian tribes.

The initial response to the symposium was less than anticipated. The installation-level NEPA practitioners don't appear to have been using DENIX. Whereas DENIX has been up and running for several years now, many of the NEPA practitioners currently are contractors (who are prohibited from symposium participation through DENIX, as currently implemented) of whom many do not have access to the NEPA webpage. This response and interpretation will be the subject of specific recommendations to the OSD sponsor.

The comments received to date were ordered and summarized, and other sources (as referenced) were used to augment the online dialog. The results of these considerations are presented in the following paragraphs. Special thanks are provided to the following online participants, as their participation framed the following presentation and analyses: Marilyn Ailes, Joel Ames, Lloyd H. Fanter, John Fittipaldi, Tom Heffernan, Robin M. Hoffman, Capt. Jason A. Johnston, Buddy Keesee, Langdon A. Kellogg, Catherine R. Kim, Paul A. Martin, Subroto Mitro, Joseph P. Ondek, Jean O'Neil, Stephen Purvine, Ivan C. Rosa, Randall Rowland, and Crate Spears.

Purpose

The purpose of this presentation is to provide a summary of the comments received to date from the online symposium on NEPA process improvement, with observations from DoD NEPA practitioners presented here. These observations also will form the basis for subsequent workshops and continued online discussion. The symposium will be continued, as costs are marginal and the potential for improvements is large. It is hoped that these workshops will refine initial discussions and prompt changes in the NEPA process within military services. If so, such changes and refinements will likely provide the common sense efficiencies and effectiveness originally envisioned by the framers of NEPA.

Appropriate NEPA Documentation Approval Authority

One fundamental aspect of NEPA is its desired conclusion, an "informed decision maker." The underlying notion is that an informed decision maker (aware of impacts associated with a decision) will make a good and justifiable decision, hopefully a decision that will manage environmental impacts through the selection of appropriate alternatives and mitigations. This Jeffersonian assumption regarding the motivations of the average decision maker could be argued, but, surely, an uninformed decision maker will fail to consider the environment appropriately. The challenge lies in placing the NEPA action as close as possible to the actual decision at hand.

Two types of failures occur with regard to decision-making authority; both separate the analysis from the decision. In one case, the decisions are made at a higher level in the organization, and NEPA analysis is done at the lower levels of the organization where implementation occurs. In the other case, decisions are actually made at a lower level, with "approval" at a much higher level in the organization. In some cases, analyses are done unilaterally by contractors, thus separating analyses and decision making even further.[3] In both cases, the close association of analysis and the actual decision is compromised. In the former case, uninformed decisions are made, and the subsequent NEPA analyses (and documents) attempt to justify decisions made by others, leading to considerable inefficiency. In the latter case, high authorities often feel obligated to approve NEPA analyses (and documents), even if they are far removed from the actual process, thus often reflecting a lack of trust in the process.

These "disconnects" are unfortunate, as the military decision process mirrors that of NEPA.[2] Such "tried and true" military approaches and sound decisions (goals and objectives, alternative development, alternative comparison, implementation, and leadership and management) align themselves well with the constructs of NEPA.

The simple solution to both inefficiencies lies in a linkage between authority and responsibility. A decision made at higher headquarters should be accompanied by the rationale and documentation associated with that decision. The authority must be accompanied by responsible analysis and documentation—the purpose of NEPA. Lower level (installation) decisions should be enabled and authorized by the authorities and the responsibilities at that level, including NEPA authority (approvals).

The NEPA process should not be relied upon as a mechanism to ensure organizational trust. Organizational oversight, along with any reports or communication, should establish the mechanisms to develop that trust, not NEPA. It is possible to delegate NEPA approvals as long as appropriate oversight is established through organizational authorities.

Value and Use of Programmatic Documents and Tiering

One of the underutilized provisions of NEPA and CEQ regulations is the use of programmatic documents. Tiering from a programmatic document can avoid repetitive analysis and documentation, such as multiple EAs or EISs. This approach should be particularly appealing to military organizations in which standard doctrine, equipment and activities prevail. However, the most common military usage of the programmatic approach has been on larger projects with sequential or life-cycle considerations to be addressed at a later date. However, the programmatic approach also applies to "similar actions," prevalent in the military, and for which separate, specified NEPA documents are certainly inefficient. Criteria to address significant issues for a standard category of action can be established in a generic document and site-specific, tiered documents can be easily and efficiently developed. Mitigations and other requirements can be established at a programmatic level of analysis and incorporated through a REC, if certain, specified, site-specific conditions arise.

Programmatic documents have proven useful for some large projects. The MX Milestone II EIS is a "hybrid" document incorporating the DSARC II Program Decision, testing at Vandenburg Air Force Base and the full-scale engineering development/production of the missile, with "macro" analysis of impacts associated with proposed basing models within areas (regions) of the U.S. and acknowledging the need for supplemental NEPA documentation later. Thus, separate EISs were developed for the rail garrison concept, a supplemental EIS for the air-mobile concept. Now, a final EIS (final life-cycle step) is being prepared for the Peacekeeper Deactivation/Dismantlement. At Eglin Air Force Base, the range-wide EIS, while stalled at the DOPAA stage, led to a series of programmatic EAs to address the effector (what is being done) and the receptor (what could be impacted) relationship at individual test areas (air, land and sea). Real savings were still obtained with the programmatic approach, both in money and staff time.

Some issues arise regarding the potential dilution of "tiered" documents and the need for initiation of the programmatic document at the appropriate decision level. In the former case, the programmatic document must establish guidelines and "rules of engagement" which ensure that a "tiered" document adequately addresses any appropriate issue, local conditions, etc. In the case of NEPA analysis at the right decision level, the best installation-level efforts can quickly and easily be stalled by failure of high authorities to consider NEPA issues when higher-level decisions are being made. The Description of Proposed Action and Alternatives (DOPAA), often a high authorities issue, is a common challenge and a major hurdle in the path of an efficient NEPA process. Installations often "swim upstream" to identify basic issues associated with a project or program, before they can address their implementation.

Not all programmatic attempts succeed. The Joint Strike Fight program tried to address the concept demonstration test and EMD test in one document. Negative comments were received because hard data was not available for the analysis, only predictions. The Army base realignment and closure process successfully addressed the inability to define specific conditions through the "bracketing" of impacts (using "intensity-based" reuse scenarios) [5] and the requirement of supplemental analyses if the brackets were exceeded (once specific data on actual reuse is available).

Differentiation Between Environmental Assessments and Environmental Impact Statements

The EA, as envisioned by NEPA, is a "hard look" at the potential environmental impacts of a proposed project or program, determining the need for more detailed analysis (the EIS), and focusing further analysis (through the EIS) on issues important to the decision makers. The EIS, as envisioned by NEPA, addresses the "show stoppers," or those impacts that should be known and evaluated by the decision maker and the affected public. An EIS should not detail every conceivable issue associated with the proposed project or program. The categorical exclusion (CX) is designed as a pragmatic, statutory mechanism to eliminate irrelevant analyses. Irrelevant analysis includes those actions that never have an impact (it is presumed that the establishment of a CX is dependent upon some historical record, such as a series of EAs on a particular category of action, all ending in a finding of no significant impact [FNSI]). Both EAs and EISs are commonly viewed as much too large and costly in DoD, often apparently judged by size not content. Therefore, new measures should be contemplated in DoD to streamline and shorten processing the interest of concern.

In practice, EISs are used, in lieu of an EA, as "cover" for "late" initiation of NEPA in the project planning process, often attempting to "craft" a "CX-based" plan to preclude an EA during this planning period. Once a CX is eliminated as an option (often through legal review), an EIS is immediately initiated (as time is too short for an EA first). In this case, the value of an EA is lost as an intermediate (evaluative) step in the process.

Without the EA to help focus the analysis, issues are often covered in unwarranted detail in an EIS. Alternatively, proponents often choose mitigated EAs (actually EISs in EA clothing) that "promise anything" to elude EIS preparation. The mitigated EA approach is sometimes successful at eluding public scrutiny, it also forces the analysis of impacts, consideration of mitigations and the lessening of project impacts (all fundamental NEPA goals). However, if the proponent does not properly implement promised mitigations, this could cause undue vulnerability, leading to litigation. The public sees this approach as the ploy that it often is.

NEPA and its associated documentation were meant to assist and inform the decision-making process. The CEQ report strongly encourages the use of the process, not the document, to accomplish the goals of NEPA.[1] This should be easily accomplished in the military, as this process is already outlined in leadership doctrine. When serious enough impacts are perceived, the EIS should further analyze, mitigate and inform the decision maker and the public. While the EIS stage of the processes can be improved through focus, the major challenge will lie in the production of EAs that are short (about 20 pages) but constitute a "hard look," as a "screening" mechanism to focus subsequent EISs on important issues. Once incorporated, the NEPA process can provide for better decisions.[1,4]

Overall Management of the NEPA Process (Including Cost and Mitigation Tracking)

In-house analysis at the early stages of the NEPA process—consideration of CXs and preparation of EAs—can save both time and money, as it often takes as much time to edit and correct contractor-produced EAs as it does to write the EA entirely. Required institutional knowledge permeates the in-house staff, while a "learning curve" is required by any contractor. All too often, the contractor is weeks (or months) into a project before a complete Purpose and Need (P&N) or DOPAA is either produced (often by the contractor) or provided. Both the P&N and the DOPAA are agency responsibilities and necessarily must be developed by in-house staff, and at the formative stage of the planning process. Their absence can preclude efficient NEPA analysis.

When determining appropriate level of NEPA analysis (EA, CX, EIS), institutional checklists, for use by both NEPA coordinators and proponents, can control costs and paper creep, "screening out" those NEPA analyses that should legitimately end as an EA/FNSI. A similar, though more complex, process could be developed for military EAs, applying specific tools (simple models or other screening tools) to identify the need for more (perhaps contracted) analysis and public involvement.[6] A good tracking system is needed for mitigation actions, particularly if the mitigated EA is a common product of agency NEPA processes.

Once NEPA documentation is done, the agency oversight "follows up" on mitigations, to ensure that they are done (enforcement) or that they work (effectiveness). The public and regulators sense (rightly or wrongly) that the "mitigated EA" is often a ploy to "skirt" EIS preparation, minimize public exposure or circumvent NEPA. The proponent should monitor mitigations for both enforcement and effectiveness, and the public should have access to any monitoring. Additional agency oversight (e.g., a major command [MACOM]) should be provided to insure that monitoring becomes "part of doing business."

Collaboration in the NEPA Process

Although true collaboration is the cornerstone of good NEPA practice, federal agencies find such "sharing" and "response" difficult, and the inclusion of the public and NGOs into such processes is also difficult. In addition, the failure to build positive "trust" through such collaboration is often the "root cause" of NEPA litigation.[7]

Within the military, collaboration also has proven difficult within and among the component services. The acquisition community often charges forward with NEPA analysis for a new weapon system without consideration for the downstream acquisition-based life cycle effects of the weapon system ("bed-down" at the installation or disposal after service). This approach leads to segmentation of the analysis rather than collaboration on the potential effects and plan of action for the "whole" system life cycle (as required by DoD Regulation 5000.2R). The solution to this particular "disconnect" is the use of the systems engineering process to identify system environmental characteristics and the generic (non-site-specific) impacts that the system will generate. These characteristics must be articulated to the "downstream" Army components to address (or articulate) potential subsequent life-cycle issues. If better collaboration is achieved, installations will have sufficient information to develop NEPA analyses for the later aspects of the system life cycle, providing time and opportunity to minimize subsequent impacts. However, the systems engineers also will benefit from the collaboration, as feedback (limitations) on concepts can be obtained early enough to change a system design.

Connected Actions and Cumulative Effects Analysis

Actions are determined to be "connected" or "separate", often based upon the project schedule, and the perceived effect on mission support (a concept particularly important in the military). Arbitrary separation of related actions is often done for the convenience of the proponent, as the environmental staff seldom wants to be viewed as the "long-pole" and strives to support the service mission. While the actual overall responsibility (the "long pole") should rest with the proponent for all connected actions, that person is often far "upstream" from an installation environmental office, where NEPA often is finally done (also see Section 1 of this paper "Appropriate NEPA Documentation Approval Authority").

Technology such as high resolution imagery, coupled with spatial analysis tools allow "snapshots in time" that visually capture cumulative effects of military actions (including other past actions) and can lead to the effective development of "carrying capacity" models and a means to effect adaptive environmental management (AEM).[2] Such tools may allow a practical, cost-effective means to both monitor effects and address the cumulative impact analysis (CIA) issue, which will otherwise prove large in scale and effort. While the development of a systematic approach can benefit from the recent CEQ guidance, each agency (DoD, DA, etc.) will have to structure some specific guidance and tools, which supports regional and interagency collaboration to address the issues of "past, present and future" actions.[8] Such tools also would address the agency-specific issues that cumulatively contribute to regional issues and challenges.

The adequacy of CIA is still a potentially litigious issue, given the conjecture and speculation that accompanies determination of what is "realistically foreseeable and reasonably connected." Good, defensible CIA will be based on reasonable forecasting, considering the cumulative impacts of the past and present developments along with foreseeable potential future developments within a predictable and pragmatic time frame.

Public Involvement

Many proponents are confused regarding two similar terms "public affairs" and "public involvement." The former term appears to mean a one-way communication, whereas the latter term, in NEPA parlance, implies the use of public input in framing the decision (to include identification or the definition of project alternatives). Public involvement should actively and honestly seek the public voice, incorporating opinions and concerns along with other factors when determining a course of action, in the best interests of the nation. Members of the public are major stakeholders in this process and the military should "reach out" and encourage their involvement. A truly informed decision will include and consider the views, opinions and concerns of the public, and every effort should be made to identify and contact potentially interested members of that public. All unclassified information should be released to the public upon request. Any risks or other potential adverse consequences should be carefully, clearly, and honestly communicated, and all information (whether in news releases, briefings, exhibits, poster board sessions, speeches, flyers or otherwise) should be designed to ensure ease of understanding. This is especially important as we work to communicate technical issues, especially those associated with potential public risk.

Integration of Environmental Justice

This aspect of NEPA practice can be expressed as three stages: identification and location of target populations (minority or low income), determination of impacts and their "disproportionality," and specialized requirements for the participation of those populations in the NEPA process.

Administrative Record

This aspect of NEPA is often overlooked, a detriment to the federal agency once litigation occurs. The administrative record establishes the "facts" upon which litigation either will succeed or fail, and improperly documented actions and considerations can weaken even a good case.

The development of a workable, pragmatic CX program can be accomplished through the use of such records as well. NEPA, by construct, established the CX mechanism to delete those "categories" of actions that would never have an impact on the environment. A good administrative record of analysis (EAs) would go far to strengthen and focus the establishment of such CXs, if accompanied by a systematic approach to CX determination and management.

Alternatives

Alternatives are often the weakest link in NEPA analyses, although they are often considered the "heart of the NEPA process." Additionally, sound military decision making is often predicated on first determining the objective and then arraying alternative approaches.[2] Given this decision-making tradition, established in military doctrine, alternative approaches should be viewed as a valued addition to the process.

Mitigation

Mitigations are increasingly important in the NEPA process, figuring prominently in NEPA strategies in DoD, as well as other federal agencies. The "mitigated FNSI" (or "mitigated EA") is a manifestation of this trend, incorporating mitigations as a special form of an alternative, and reducing impacts below the significance threshold that would require a formal EIS. This reliance on mitigations is false security unless the responsible agency ensures the successful implementation of mitigations; otherwise they are a circumvention of the NEPA process.

In all NEPA cases, outside of those discussed above, mitigations should be linked to some form of monitoring, either enforcement (Were they done?) or effectiveness (Did they work?). The former can ensure credibility and the latter can ensure the effective investment of scarce resources. This monitoring system also can provide needed process improvements, ensuring that inadequate or ineffective mitigations are deleted as alternatives, otherwise scarce resources are wasted with no benefit to the environment.

Base Realignment and Closure (BRAC)

There is growing emphasis and appreciation for biodiversity on military lands.[9] As BRAC installations go through the NEPA process, areas of important biological diversity are increasingly identified on closing bases. While there is substantial DoD effort to examine the issue of biodiversity conservation on active military lands, current DoD biodiversity guidance does not really address procedures that would ensure the long-term protection of biodiversity on bases that are closed or transferred. DoD Instruction 4715.3 "Environmental Conservation Program" states: "The natural and cultural resources identified on installations proposed for closure shall be addressed during disposal and reuse planning" (e.g., 40 CFR 1500-1508 and Section 4341 of 42 U.S.C.). To meet the military environmental responsibilities, land use restrictions may be required on property transferred to others. As an example, Fort Ord produced a Habitat Management Plan, written as part of the EIS. The EIS ROD assigned mitigation implementation and monitoring to federal, state and local agencies, as well as conservation organizations such as the Nature Conservancy and Coastal Conservancy. New owners will subsequently be expected to comply with the requirements of the plan.

While CEQ has provided specific guidance for the inclusion of biodiversity into NEPA, further agency guidelines will be required to address the long-term responsibilities for resource protection on BRAC property.[10] The Army BRAC NEPA process effects such resource protection through "encumbrances" placed on transferred lands.[5] While lawyers often focus narrowly on statutory and regulatory requirements, the "right thing" often goes beyond simple compliance. While these encumbrances are often "negotiated out" through internal legal review, land recipients are still "encouraged to honor such provisions presented in the NEPA analysis."

NEPA and Indian Tribes

In DoD service NEPA guidelines (DoD policy signed by the SECDEF in 1988), the terms "federal," "state" and "local" reference those entities requiring specific public involvement and collaboration. To ensure that potential Tribal impacts are addressed, entire guidance documents could be reviewed and changed to read, "federal, tribal, state and local." In addition, the issue of consultation and government-to-government relations with federally recognized tribes should be clearly addressed. Any NEPA guidance should address (a) tribal cultural and religious practices, usual and customary food gathering, protection and the access to and use of Cultural and Religious Sites, (b) the Native American Graves Protection and Repatriation Act, and (c) rights afforded by treaty and other legal doctrine (in addition to any other potential impacts). Another issue is determining impacts that affect tribes that once had ancestral lands on or near installations.

Regarding the question of more detailed guidance for actions specifically affecting tribes, the current Army approach uses the implementation regulation to identify "what" is required, as a matter of policy, and the use of subsequent guidance ("how-to" manuals or pamphlets) to address the "how" this is accomplished. This hierarchical approach should provide ample justification for doing the right thing (through the regulation definition of "what") and maximum flexibility (through the guidance manuals establishing "how"). Any issues addressed through regulation are less likely to be overlooked. Through the use of specific "how-to" manuals, unique consultation requirements with recognized American Indian Tribes could be delineated in some detail outside of a "codified" process, and even regional issues can be addressed through specific guidance mechanisms.

Summary

A review of the NEPA statute itself uncovers a strong vein of common sense, allowing considerable discretion to the agency decision maker, and encouraging initiative and innovation.[11] Such initiative and innovation should allow agencies to make NEPA a tool that supports decision-making and does so in an efficient manner. The 1978 CEQ regulations strengthen the "common sense" approach, calling for shorter documents and "better decisions," in lieu of "more documents."[12] The sources of inefficiency and the basis for ineffective implementation lie in agency implementing regulations and other agency interpretations, whether explicit or implicit, of CEQ's NEPA regulations and guidelines. While all formal guidance encourages initiation of pragmatic NEPA analyses "early" in agency planning and decision-making, the process still is often long and laborious (placing it late in the decision making life cycle) and leads to substantial costs (and questions regarding efficiency) with little benefit to the decision maker. Agency leadership often remains oblivious to the real intent and potential value of NEPA analyses, instead relying on legal or professional environmental staffs whose goal of a "bullet-proof" document often overshadows the value of analyses to the decision maker. In fact, "We have met the culprit, and it is us!"

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The Public and the Commenting Process for the Proposed Grand Kankakee Marsh National Wildlife Refuge

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The framers of the National Environmental Policy Act (NEPA) envisioned a procedural model for voluntary integration of environmental values into federal policy. Thirty years later, the environmentally-aware viewpoint still holds that NEPA provides an agenda for society-wide participatory planning for a preferred future (Caldwell 1998). How well federal land management agencies have been able to balance public involvement with technical expertise in the decision-making process provides one measure of NEPA success.

The public commenting period required in Council on Environmental Quality (CEQ) regulations for NEPA implementation (40 Code of Federal Regulations [CFR] 1500-1508, 1978) represents an excellent opportunity for citizens to become active participants in the planning of environmentally significant federal agency projects and programs. However, the ways in which federal agencies choose to accommodate this opportunity, often create an adversarial relationship between agency and stakeholder. A common perception of NEPA as a cumbersome federal regulatory process is reinforced when advocacy or citizen groups challenge an agency's proposed action on the basis of inattention to concerns expressed during the commenting period. Such disputes are expensive, inefficient and time-consuming. To avoid litigation and delays, agencies should reach out to all interested and affected parties and determine the scope of their concerns early in the planning process. The amount of public involvement should reflect the public's level of interest in the proposed project (Eccleston 1999).

Early public involvement acquires additional importance in the context of growing agency reliance on the environmental assessment (EA) as a vehicle for NEPA compliance that avoids preparation of full-blown environmental impact statements (EISs). A substantial decline in the preparation of EISs by federal agencies has occurred over the past 25 years with a concomitant increase in the numbers of EAs prepared (EPA 1999).

The CEQ regulations for NEPA implementation define the EA as a concise public document designed to provide sufficient evidence and analysis for determining whether an agency proposal requires the preparation of an EIS or a finding of no significant impact (40 CFR 1508.9[a][1]). Although the CEQ regulations assert that "an assessment is not necessary if the agency has decided to prepare an environmental impact statement (40 CFR 1501.2[a])," they also state that "agencies may prepare an environmental assessment on any action at any time in order to assist agency planning and decision making (40 CFR 1501.3[b])."

The EA functions as an intermediate compliance mechanism for the agency reviewing a proposed action considered likely to result in a Finding of No Significant Impact (FONSI). Furthermore, as noted by Eccleston (1999), the EA does provide an excellent general purpose vehicle for agency coordination and planning. However, the documented trend in reduction of EIS preparation in favor of EAs has negative implications for public participation opportunities (Blaug 1993, Solomon et al. 1997). Results of a 1992 survey sent to the NEPA coordinator of every federal agency by the CEQ confirm that EA preparation has far outpaced full EIS preparation as the most frequently employed tool for investigating potential impacts (Blaug 1993). While ultimately concluding that conscientiously prepared EAs can achieve NEPA compliance and facilitate the decision-making process, Blaug (1993) expresses concern that some agencies are preparing EISs "disguised" as EAs under the misconception that EA preparation does not require public participation. The EA, however, is a "public document" (40 CFR 1508.9). Although not charged with conducting a formal comment, review and incorporation period, agencies are required to make provisions for public involvement when preparing an EA for NEPA compliance (Eccleston 1999).

Environmental assessment preparation is appropriate in situations in which the agency is genuinely uncertain whether a proposed action will result in a significant impact. Environmental assessment preparation also is appropriate in situations in which the agency is reasonably confident that impacts will be deemed nonsignificant or where mitigation is acceptable. Solomon et al. (1997) point out that the trend toward increased use of EAs can be attributed to the 30 years of experience agencies now have with NEPA implementation. Today, federal agencies tend to dismiss the most ecologically-damaging and unpopular projects earlier in the decision-making process (Dickerson and Montgomery 1993). Agencies also are better able to predict which types of proposed actions (e.g., siting, construction, and operation of nonhazardous waste storage or water treatment facilities) will normally require an EA leading to a FONSI (Blaug 1993, Eccleston 1999).

Potential problems with EA preparation arise from the fact that, although CEQ regulations require federal agencies to provide and be accountable for public participation opportunities, the regulations leave the particulars for EA public involvement to the discretion of the agencies (Solomon et al. 1997, Eccleston 1999). A procedure for early identification of affected communities where notification, dissemination and environmental education efforts should be concentrated would enhance the efficiency of the EA public involvement period.

This paper examines the process leading to a recently issued finding of no significant impact for the proposed Grand Kankakee Marsh National Wildlife Refuge by the U.S. Fish and Wildlife Service (1999). The response structure of written comments sent to the Service during the scoping process associated with the draft environmental assessment (Fish and Wildlife Service 1998a) is related to geographic distribution and social capital indicators from affected counties. The paper concludes with a discussion of the need to refine techniques for integrating social values more fully into the impact assessment process, even for a less contentious proposal such as siting a national wildlife refuge.

The Proposed Action: A New Wildlife Refuge

The Agency

The U.S. Fish and Wildlife Service (FWS) is the primary federal agency responsible for conserving, protecting and enhancing America's fish and wildlife resources and their habitats. As part of this mission, the Service administers a national network of refuge lands and waters specifically managed for fish and wildlife (Fish and Wildlife Service 1999). Although NEPA compliance in other federal agencies has been studied extensively (Carter 1987, Clary and Kraft 1989, Culhane 1991, Oh 1992), the FWS NEPA process has received relatively little attention in the literature (*see* Mangun 1989).

The NEPA environmental impact assessment process, as conducted by FWS in the recent past, was directed toward broad management actions rather than site-specific projects, with the notable exceptions of siting or assessing alternative uses for refuge lands (Mangun 1989). More recently, the largest number of FWS environmental impact assessments have dealt with endangered species actions, such as habitat conservation plans (HCPs) and incidental take under Section 10 of the Endangered Species Act (ESA), as well as recovery-related activities. Other proposed actions that have become more frequently assessed are associated with comprehensive conservation plans, rights of way and cooperative efforts with state and local governments through FWS Federal Aid programs (Peterson personal communication: 2000).

Consistent with CEQ evaluation of current NEPA compliance mechanisms at federal agencies (Blaug 1993), the FWS (1998b) reports preparation of "a number" of EISs as compared to approximately one thousand EAs prepared annually. The argument may be made, however, that within FWS, an EA function as an appropriate decision-making aid assisting managers in the field with coordination and planning of proposed agency actions. Tabulation of the exact number of FWS EAs is complicated by the fact that most are prepared at the field level (i.e., by refuge and ecological services personnel). However, FWS regional and headquarters personnel also prepare EAs, particularly those dealing with programmatic assessment (Peterson personal communication: 2000).

Many FWS proposed actions, such as establishment of a new wildlife refuge, not only would be reasonably expected to result in a FONSI, but they would be viewed in a positive light by much of the environmental community. One could hypothesize that these factors contribute to why the FWS exhibits a different pattern of NEPA compliance mechanisms than other federal land management agencies — most notably the USDA-Forest Service (USDA-FS) and the Bureau of Land Management (BLM). A recent U.S. Environmental Protection Agency (EPA) summary of EIS activity from 1992 to 1998 for selected federal agencies indicates that USDA-FS filed more than 100 EISs and BLM up to 50 EISs annually over this time period (Environmental Protection Agency 1999). Many USDA-FS and BLM proposed actions are traditionally of a commercial nature involving timber harvest and mining that are routinely challenged by environmental activists. The USDA-Forest Service and BLM also are required to complete resource management plans for national forests and BLM units under the National Forest Management Act (NFMA) and the Federal Land Policy Management Act (FLPMA), respectively. These management plans require detailed environmental impact assessments and often involve reconciling activities of a conflicting nature as related to the agencies' multiple-use mandates (Culhane 1981, Oh 1992, Steelman 1996).

As FWS proposals begin to present and assess more controversial management alternatives, the relative numbers of EAs and EISs prepared by the agency may be subject to change. For example, many management actions required under the ESA involve land-use restrictions that potentially impinge upon private property rights. Conversely, if environmental activists perceive HCPs as leading to reduced protection of endangered species, additional demands for more detailed environmental impact assessments and the potential for litigation can arise. Ultimately, the agency will bear the responsibility for engaging the public in the NEPA process and ensuring that the concerns of minority opinion stakeholders are addressed (Solomon et al. 1997).

In August of 1999, the FWS issued a final environmental assessment document for the proposed Grand Kankakee Marsh National Wildlife Refuge (GKMNWR) that presented justification for selection of a preferred management "action" alternative leading to a finding of no significant impact (Fish and Wildlife Service 1999). Substantial provision for public involvement had been built into the scoping process associated with the draft environmental assessment during an extended 150-day comment period. During that period, more than 14,000 people inquired or commented on the proposed refuge (Fish and Wildlife Service 1999). To date, no substantive appeal has been leveled against the planned action.

The Affected Area

The former greatness of the Grand Marsh, which once covered a large part of the Kankakee River Basin of northwestern Indiana and northeastern Illinois, has been well-documented (Isaacs 1964, Ivens et al. 1981). The marsh was part of one of North America's largest freshwater wetland complexes covering about 1 million acres (400,000 ha). Before channelization efforts intensified in 1906, the Kankakee River meandered its way from its headwaters in South Bend, Indiana, to the Illinois state line following a winding 200 mile (320 km) course that traversed 80 miles (130 km) (Fish and Wildlife Service 1999, Clark and Slusher 2000). The recurrent bends combined with a gradient of only 5 inches (12 cm) per mile (2.6 km) to create a giant wet prairie environment. Numerous prairie-wetland plant and wildlife species flourished, as did the activities that these resources supported (Sweeney 1998).

Historically, agriculture played an important role in the development of the northern Indiana/northern Illinois regional economy (Shively and McNamara 1998). Drainage and channelization projects conducted during the first half of the twentieth century were designed to put land into agricultural production and reduce flooding. Agriculture has continued to impact the region economically and ecologically. After channelization, the Kankakee River functioned essentially as an agricultural drainage ditch for farmers on the Indiana side of the watershed. Looking westward from the Illinois/Indiana state line, however, the Kankakee still flowed through natural winding channels, high-quality shrub swamps and bottomland forests (Fish and Wildlife Service 1999). Growing public interest in preserving what remained, as well as restoring portions of what had been lost, led to the present FWS involvement.

In 1996, the U.S. Fish and Wildlife Service initiated a planning process for evaluating the feasibility of a new wildlife refuge in the Kankakee River Basin. The intent of the proposed GKMNWR was not to restore the entire Grand

Marsh, but rather to preserve 30,000 acres (12,140 ha) of remnant and restorable wetlands, oak savanna and prairie within the 3.3 million acre (13,378 km^2) basin (Fish and Wildlife Service 1999). The entire freshwater drainage crosses state boundaries and includes all or part of 6 Illinois counties, 13 Indiana counties, and 1 Michigan county. Within the watershed, FWS has identified scattered tracts of land suitable for restoration and preservation. In order to achieve its objectives, FWS intends to employ a cooperative public/private approach of conservation easements, multi-organizational partnerships and land-acquisition methods. All land acquisition by FWS in the Kankakee River Basin is planned to be on a willing-seller basis over a projected 30-year period (Fish and Wildlife Service 1998a).

Distribution and Dimensions of Response

Methods

Because of the proposed refuge's location across agricultural landscape in close proximity to metropolitan areas, written public comments received by FWS during the draft EA scoping process originated from a wide range of rural and urban settings. FWS personnel prepared a database to support a preliminary content analysis of this correspondence using FileMaker Pro, Release 3.0 software (Claris 1995). This database was imported into SPSS for MS-Windows, Release 10.0 (SPSS 1999), cleaned, recoded and prepared for subsequent statistical analysis. Univariate frequencies were used to describe the distributions of the geographic origin and opinion content of the comments. Bivariate contingency table analysis and the Chi-square test statistic ($p \leq 0.05$) were used to analyze relationships between categorical variables (e.g., comment state-of-origin and support for the proposal).

Binary logistic regression was used to determine the ability of a set of predictor variables to estimate the probability of an outcome that was expressed as a dichotomous dependent variable. Our logistic regression model examined the ability of arbitrarily selected social capital indicators to predict the comment author's support or lack of support for the proposed refuge. To reduce the number of cases entered in the analysis, only comments originating from the 19 Illinois/Indiana Kankakee Basin counties were included. The Nagelkerke R^2 statistic, which is similar in intent to the R^2 in a linear regression model, was used to quantify the proportion of explained variation in the logistic regression model (Norusis 1999).

Social capital indicators were interpreted as a set of socioeconomic and demographic community descriptors that can be combined into an index and used in subsequent trend analyses of community well-being (Tyler Norris Association 1997). As the grouping variable of our data set was county of residence, we selected social and economic statistics from the 1990 Census, which were measured at the county level (U.S. Census Bureau 1998), and merged these data into the SPSS data file. The social variables selected for input into the logistic regression model were: average household income; percent of people of all ages living in poverty; size of rural population; number of farm operators by principal occupation; and educational attainment, measured as number of bachelor's, graduate or professional degrees. These variables were chosen as surrogate measures of a county's quality of life.

Results

The 13,974 written comments received during the scoping process associated with the draft EA for the proposed GKMNWR originated in 44 states and one foreign country. The percentage in support of the proposal was 65.8, 32 percent were opposed, and 2.2 percent of comments were unclassified in the original database. For purposes of this analysis, only those comments originating in Illinois and Indiana were examined in detail. Four thousand two hundred comments were received from 49 out of 102 Illinois counties; 9,040 comments were received from 59 out of 92 Indiana counties. A breakdown of comments by counties contributing one percent or more to the total number of comments is presented in Table 1.

Due to the high number of Illinois/Indiana counties represented, a contingency table analysis relating comment geographic origin to support for the refuge was conducted at the state level. The distribution of opinions, as illustrated in Figure 1, was found to differ significantly between the states ($P^2 = 904.42$, df $= 4$, $p < 0.01$, Cramér's $V = 0.18$, approx. sig. < 0.01). Indiana residents exhibited higher overall support for the refuge proposal. Likewise, whether the written comment was prepared in personal or form letter format was found to differ significantly between the states ($P^2 = 1{,}123.32$, df $= 4$, $p < 0.01$, Cramér's $V = 0.22$, approx. sig. < 0.01). A higher percentage of Indiana residents used personal letters as compared to Illinois residents.

The strong relationship between geographic origin and the absolute number, content and form of comments led us to consider if a combination of resident county characteristics could predict an individual's support or lack of support for the proposed refuge. The logistic regression analysis (both enter and stepwise methods) produced a classification table indicating that 82.6 percent of cases were predicted correctly overall (Table 2). The independent predictor variables were slightly better at predicting who would not support the proposed refuge (85.8 percent correct), as opposed to who would support it (79.7 percent correct). All five predictor variables were included in the logistic regression model. Our analysis yielded a Nagelkerke R^2 value of 0.512, which is inter-

Table 1. Frequency of public comments received on the proposed Grand Kankakee Marsh National Wildlife Refuge from counties in Illinois and Inidana.

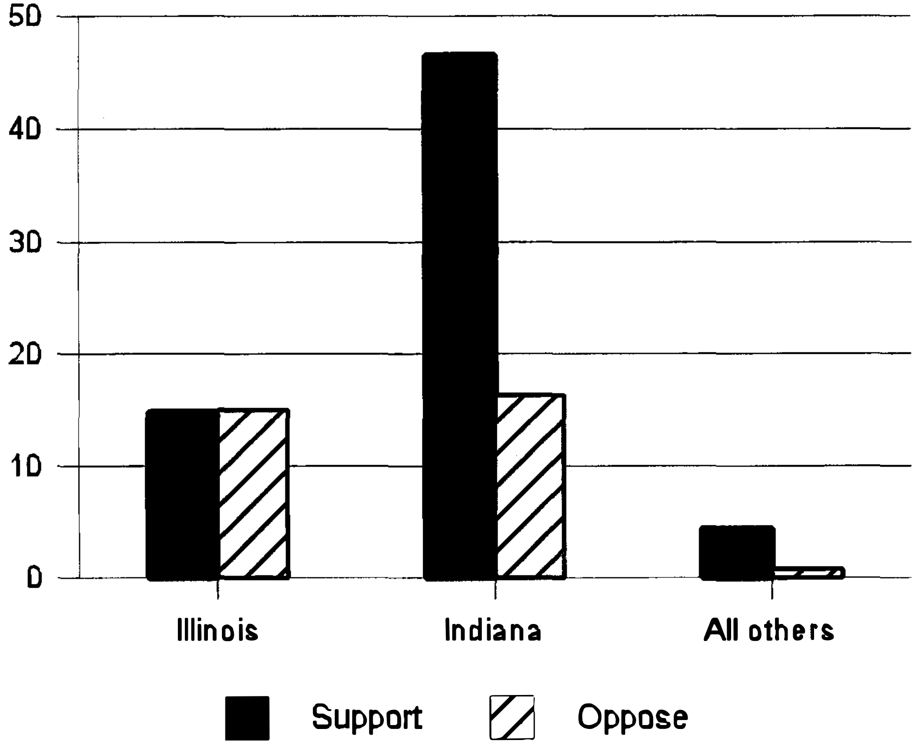
State	County	n	Percentage
Illinois	Cook	1,411	33.6
	DuPage	93	2.2
	Iroquois	115	2.7
	Kankakee	1,964	46.8
	Will	306	7.3
	All other Illinois counties	297	7.4
	Total	4,200	100.0
Indiana	Allen	303	3.4
	Elkhart	176	1.9
	Jasper	580	6.6
	La Porte	294	3.3
	Lake	2,272	25.1
	Marion	291	3.2
	Marshall	253	2.8
	Newton	426	4.7
	Porter	435	4.8
	St. Joseph	595	6.6
	Starke	1,046	11.6
	Steuben	615	6.8
	Tippecanoe	653	7.2
	Wabash	97	1.1
	White	86	1.0
	All other Indiana counties	895	9.9
	Total	9,040	100.0

Table 2. Logistic Regression Classification[a] for prediction of support for proposed refuge.

	Predicted opinion		
Observed opinion	Support	Do not support	Percentage correct
Support	3,521	896	79.7
Do not support	577	3,492	85.8
Total percentage			82.6

[a] The cut value is 0.500

Figure 1. Output from cross-tabulation of categorical variables comment state-of-origin and support for proposal.



preted to mean that 51 percent of the variation in the outcome variable was explained by the logistic regression model.

Although this analysis was designed to be of an exploratory nature only, the results demonstrate that development of a predictive model of public support for agency actions does have potential. The coupling of a predictive model with a geo-referenced database would provide a powerful tool for focusing agency notification, dissemination and environmental education efforts.

Discussion and Recommendations

Public involvement is vital to the NEPA compliance activities of any federal agency in that it provides: a mechanism for exchange of information between the agency and the various publics, a value context for assessment interpretation, and a source of credibility for the decision-making process (Creighton et al. 1983). Critics of public involvement in government decision making cite its inefficiency in identifying public preferences and synthesizing them into coherent public policy (Oh 1992). Solomon et al. (1997) observe that recent trends toward collaborative planning and attitude changes among agency decision makers are positive signs that public involvement will increasingly influence the NEPA process.

As approximately 14,000 written comments would indicate, the public now has considerable interest in FWS activities (Eccleston 1999). FWS Director Jamie Rappaport-Clark has directed the agency to promote public participation in decision making, including the EIS/EA process (Peterson personal communication: 2000). However, FWS held only five public meetings in affected communities during the scoping process for the proposed GKMNWR (Fish and Wildlife Service 1999). An examination of the response structure of the written comments received by FWS has important practical implications for development and refinement of an agency decision-making paradigm that satisfies public involvement needs. Additional importance is derived from the fact that, in cases of contested agency decisions, the courts have consistently upheld decisions in which agencies are able to demonstrate a reasonable compliance with the public involvement process (Solomon et al. 1997).

We suggest that a better choreographed approach, which tailors dissemination and education efforts according to the participatory potential of a community, county or other geographic location, would better facilitate the goals of the EA public comment period. Land suitability and programmatic assessments should also take social values into account. Initial refuge design for the GKMNWR already used an interactive geographic information system (GIS) program that incorporated biological and physical data in the reserve siting process (Clark and Slusher 2000). A capacity to demonstrate the geographic distribution of social data would facilitate its eventual incorporation into similar GIS-based analyses.

Identification and integration of additional social capital factors that foster responsive citizenry and provoke community involvement can help agencies better anticipate areas of public opposition or support for a proposed action. In addition, a record of this nature would provide the documentation that the agency indeed has made the required "diligent efforts" to involve the public during the planning process.

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Integrating NEPA with Other Environmental Laws: Road Map for Success

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Proposed federal activities that trigger review under the National Environmental Policy Act (NEPA) often require compliance with other federal and state environmental laws. When compliance with other laws is required, participating federal lead agencies must integrate these laws with NEPA.

In practice, successful integration of NEPA and other laws has proven to be complicated, confusing and frustrating for the professionals who must achieve compliance with requirements that often conflict. However, according to the President's Council on Environmental Quality (CEQ), successful integration is not only vital to meeting NEPA's objectives but is a key indicator of its effectiveness (CEQ 1997).

While NEPA's integration requirements often are complicated and misunderstood, effective and proven methods for successful integration do exist. In this evolving aspect of NEPA practice, agencies must be creative and flexible to achieve integration in an efficient and coordinated fashion. This paper explains how federal agencies can achieve NEPA's objectives while at the same time satisfying the legal requirements of other environmental laws. It also summarizes the integration requirements under NEPA and offers suggestions for making integration work in practice.

Integration Requirements of NEPA

CEQ NEPA Regulations

The NEPA regulations issued by the CEQ specifically require federal lead agencies to integrate the NEPA process with other environmental laws and regulatory requirements to the fullest extent possible (40 C.F.R. 1502.25[a]). Thus, each time a federal agency prepares an environmental impact statement (EIS) or an Environmental Assessment and Finding of No Significant Impact

(EA/FONSI), it has an obligation to determine which other environmental requirements may be applicable to the proposed action, list in the NEPA document all permits, licenses and other consultation requirement for the project, and to integrate such requirement with NEPA to the extent possible.

The Theory Behind Integration

The requirement to integrate NEPA with other laws is based on the twin goals of avoiding duplication and reducing delay in the evaluation of projects. Many environmental laws have similar evaluation and documentation requirements. If each such requirement were implemented separately, there would be a high likelihood of duplication of effort and cost, potentially resulting in different and conflicting conclusions. Further, without the integration of legal requirements, laws would be satisfied sequentially rather than simultaneously, resulting in excessive delays. One of the fundamental premises of NEPA is that only one environmental impact document should be prepared (by the lead agency) for each project and that other agencies should rely solely on that document to satisfy NEPA. Integration of environmental laws helps achieve this "one project, one document" concept.

Determining Which Laws Must Be Integrated with NEPA

Federal Environmental Laws

Every proposed federal action will trigger a different set of related environmental requirements, depending upon the type and location of the activity being proposed. For example, the replacement of a historic bridge across a navigable river could trigger the need for U.S. Army Corps of Engineers permits under Section 404 of the Clean Water Act (33 U.S.C. sec 1344) and under Section 10 of the River and Harbor Act (33 U.S.C. 403), a permit from the U.S. Coast Guard under Section 9 of the River and Harbor Act (33 U.S.C. 401), consultation with the U.S. Fish and Wildlife Service under Section 7 of the federal Endangered Species Act (16 U.S.C. 1536), review of historic resources under Section 106 of the National Historic Preservation Act (16 U.S.C. sec 470[f]), a review of publicly owned lands or historic sites under Section 4(f) of the U.S. Department of Transportation Act of 1966 (49 U.S.C. sec 303), and conformity with requirements of the U.S. Clean Air Act (42 U.S.C. 7401). In situations such as this, the review, consultation, evaluation, and documentation requirements of these other laws must be integrated into the NEPA process. (Obviously, a project that did not involve a waterway would trigger a different set of legal requirements.)

In addition to laws and regulations, several Executive Orders, such as those addressing wetlands (Executive Order 11990), flood plains (Executive Order 11988) and environmental justice (Executive Order 12898), require integration of special studies with the NEPA process.

State Environmental Laws

If the project is located in one of the 15 states that has a "little NEPA" law, a state-level environmental impact statement also may be required. Fortunately, most of these state laws are modeled after NEPA and have similar procedural requirements that make integration relatively easy (Bass et al. 1993). In addition to state environmental impact assessment laws, various other state environmental laws may be involved in proposed federal activities.

Developing an Inventory of Related Environmental Requirements that Must Be Integrated

Because of the complexity of environmental laws in the United States, each federal agency should develop a comprehensive list of environmental requirements that would typically apply to projects under its jurisdiction. Such a list may differ from region to region within the same agency because of differing state law requirements that apply to similar activities. Experience, environmental law text books (e.g., Mandelker 1999), and agency web sites are good sources of information about related environmental requirements.

Model Approach to Successful Integration

Need for an "Integration Work Plan"

To ensure the successful integration of NEPA with other regulatory requirements, the lead agency (often with the assistance of its NEPA consultant) must develop an "Integration Work Plan" to carefully spell out each step in an integrated process. While neither NEPA nor the CEQ NEPA regulations provide a standard methodology for integrating NEPA with other requirements, some NEPA practitioners have developed successful approaches (Bass et al. 1999, Mid-Atlantic Transportation and Environmental Task Force 2000, U.S. EPA et al.1997). Figure 1 summarizes the 10-step approach to integration discussed below.

Step 1: Identify Potential Related Environmental Requirements

As discussed above, each lead agency should develop and maintain a comprehensive list of commonly recurring regulatory requirements that would be involved in projects under its jurisdiction. Such a list will form an important starting point for the integration process.

Figure 1. Ten-step approach to NEPA Integration

Step 1: *Identify potential related environmental requirements*

Step 2: *Consult with regulatory agencies to:*
- Confirm their jurisdiction over the proposed action
- Learn the specific in their review process
- Determine the scope of any necessary technical studies
- Agree on an integrated processing and review schedule

Step 3: *Prepare a written "Integration Work Plan" that:*
- Depicts the major steps in each agency's review process
- Identifies parallel steps and common technical study requirements
- Contains an overall schedule for integrated environmental review
- Identifies responsible individuals within the lead agency staff (or consulting firm)

Step 4: *Draft and sign any necessary "Memorandum of Understanding"*

Step 5: *Conduct necessary reviews and technical studies*

Step 6: *Consolidate results into Draft NEPA document*

Step 7: *Conduct public and interagency review*

Step 8: *Add results of any late studies into Final NEPA document*

Step 9: *Adopt consolidated NEPA document.*

Step 10: *Individual agencies use NEPA document in their regulatory decisions.*

Step 2: Consult with Regulatory Agencies

After the lead agency develops a potential list of related regulatory requirements, it must consult with the other regulatory agencies to accomplish the following:

- confirm its jurisdiction over the proposed action;
- determine the specific steps in its review process;
- learn about any necessary technical studies and consultation requirements;
- agree on an integrated approach to environmental review processing; and
- establish a coordinated schedule.

Step 3: Prepare Written "Integration Work Plan"

After the lead agency confirms the jurisdiction and involvement of other agencies into an integrated NEPA process, it should prepare a written "Integration Work Plan" that provides for the following:

- depicts the major steps in each agency's review process;
- identifies parallel steps and common technical study requirements;
- contains an overall schedule for integrated environmental review; and
- identifies responsible individuals within the lead agency staff (or consulting firm).

Table 1 illustrates the concept of such an Integration Work Plan for a project in California, one of the states with a "little NEPA."

Table 1. Conceptual "Integration Work Plan"

Law	Scoping (week 4)	Draft decision (week 16)	Final decision (week 30)	Decision-making (week 34)
NEPA	Notice of intent	Draft NEPA document	Final NEPA document	Lead agency decision; Record of decision
CEQA	Notice of preparation	Draft CEQA document	Final CEQA document	State lead agency decision and findings
Endangered Species Act Section 7	Requests species list from USFWS	Biological assessment	Biological opinion	n/a
Clean Water Act-Section 404	Define objectives; screen alternatives; submit permit application to USACE	Draft Sec. 404(b)(1) analysis	Final Sec. 404(b)(1) analysis	404 permit granted
National Historic Preservation Act-Section 106	Identify and evaluate resources	Draft "effects" assessments	Memorandum of agreement between lead agency and ACHP	n/a
Clean Air Act-Confomity	Determine if conformity requirements apply	Preliminary analysis (comparison to de minimus levels)		Conformity determination issued

Step 4: Draft and Sign Any Necessary "Memorandum of Understanding"

If necessary to achieve the objectives of integration, the lead agency may want to draft one or more Memoranda of Understanding to formalize the involvement of the various parties. Such agreements often can help the agencies take integration seriously.

Step 5: Conduct Necessary Reviews and Technical Studies

To the extent possible, the individual agencies involved in an integrated review process should conduct their reviews and prepare any technical studies in a combined manner. If that is not possible, each agency should at least ensure that any studies it conducts meets the requirements of all other regulatory agencies. For example, in the case of a project affecting wetlands, when the lead agency selects a range of alternatives for the NEPA document, it should make sure that such alternatives also satisfy the requirements of the U.S. Army Corps of Engineers under Section 404(b)(1) of the Clean Water Act (*see* Integration Case Study).

Step 6: Consolidate Results of Completed Technical Studies into Draft NEPA Document

After environmental reviews and technical studies are completed, each agency should provide copies of such studies to the lead agency to be included in the NEPA document. The lead agency should then evaluate the results of the various studies to determine the degree to which conclusions are consistent, or not consistent. If, however, serious conflicts between technical studies are present attempt to resolve them the lead agency should, through further consultation and negotiation.

Agencies should remember that NEPA is fundamentally a problem-solving tool. If agencies cannot reach consensus on issues, the conflicting views should be presented in the draft NEPA document, in keeping with NEPA's full disclosure objectives.

In practice, one of the biggest problems in attempting to achieve integration is that some technical studies and consultation requirements take much longer than others. For example, the evaluation of historic resources for a typical NEPA document takes far less time than the full review and meeting of consultation requirements demanded by Section 106 of the Historic Preservation Act. Thus, often the lead agency is ready to complete the draft NEPA document while the 106 process is still proceeding. In an ideal world, lead agencies would wait until all consultation requirements are completed before publishing a draft NEPA document. However, because of soft NEPA language—"to the fullest extent possible"—this is not required. Thus, sometimes, fulfillment of related regulatory requirements must "catch up" with the NEPA process before the final document is prepared and the decision on the project is made. When this "catching up" is necessary, the lead agency should at least summarize any preliminary results of other studies and explain in detail the ongoing consultation process in the Draft NEPA document. NEPA does not allow an issue to be left out of the Draft document just because another agency is still studying that issue in greater detail than NEPA requires.

Step 7: Conduct Public and Interagency Review

Once the draft NEPA document is published, it must be made available for public review and interagency consultation in accordance with the specific requirements of each lead agency's NEPA regulations and manuals, which differ from agency to agency. The public review and interagency consultation process is an essential component of an integrated NEPA process because it allows other agencies to see how the lead agency has dealt with its issues in the NEPA document. If cooperating agencies do not agree with the lead agency's evaluation of their requirements, they may deal informally with the lead agency to resolve issues before finalizing the document. Ideally, cooperating agencies will do this to avoid having to submit written argumentative comments to the lead agency.

Step 8: Add Results of Any Late Technical Studies into Final NEPA Document

As indicated in step 6, sometimes it is necessary to add the results of related review and consultation to the NEPA document "at the last minute." This point in the process presents another opportunity to resolve any lingering disagreements with other agencies. However, if these last minute studies change the "significance" of conclusions in the NEPA document, then a supplement may need to be prepared and a new public review conducted.

Step 9: Adopt Consolidated NEPA Document

After the lead agency determines that the NEPA document is adequate and that it has done all it can to resolve disagreements with other agencies, it must adopt the document.

Step 10: Individual Agencies Use NEPA Document in Their Regulatory Decisions

In practice, even though the NEPA process is well-integrated with other environmental review and consultation requirements, regulatory agencies typically make separate decisions on the project in accordance with their respective legal and regulatory requirements. However, in an integrated process, they all use the same NEPA document in keeping with NEPA's "one project-one document" concept.

Lead agencies whose projects frequently require coordination with many other agencies have developed handbooks and manuals specifically devoted to successful integration. One such example is a manual published by the Federal Highway Administration for transportation projects (Federal Highway Administration 1997). This manual includes various recommendations for achieving successful integration between NEPA and other laws. The manual even includes programmatic Memoranda of Understanding drafted by FHWA, under which various agencies have specifically committed to cooperation on all transportation projects.

Common Problems that Cause Integration to Fail

Absence of an Organized "Integration Work Plan"

Probably the most frequent reason that integration fails is the absence of an organized "Integration Work Plan." For many projects, the integration of NEPA with other requirements is too complicated to be left to chance. Without developing a comprehensive approach, delay and duplication are likely to occur. Too often, attempts at integration are left to the "last minute" when coordination and cooperation are impossible to achieve.

Ignorance of Requirements

If the lead agency does not take the time to learn about the regulatory requirements of other agencies, full integration is likely to fail. For instance, one of NEPA's objectives is to require agencies to take an interdisciplinary approach to evaluating. If a lead agency fails to include one key agency in its NEPA process, the entire process may be delayed. It should be noted that learning about other agencies' laws and regulations may require special staff training. Toward that end, it may require agencies to involve their legal staffs in the NEPA process at an early stage.

Failure to Consult

The failure of the lead agency to consult with other involved agencies at an early stage of the NEPA process also can adversely affect attempts to integrate their respective requirements. Early and frequent communication is essential to successful integration. To be maximize the effectiveness of integration, the lead agency should consult with other agencies at each key step in its "Integration Work Plan"

Timing Problems

Another potential cause of integration failure is allotment of time for completion of the NEPA process. On occasion, agencies develop schedules for completing the process without determining how long related regulatory reviews, studies or consultations may take. In other cases, agencies develop unreasonably short schedules due to the demands of project applicants or agency officials. Either of these situations can cause timing delays and duplication of effort that defeat the objectives of NEPA integration.

Noncooperation Problems

A negative, noncooperative attitude by agency officials and their staff members also can cause integration to fail. Such attitudes can be the result of "turf battles" between agencies that are competing for control of the NEPA process or the lead role in regulating a particular resource. In other cases, the negative attitudes or non-cooperation can be specific to individuals. A flexible, positive, "can do" attitude is essential to achieving the successful integration between NEPA and other laws.

Integration Case Study

Within the five Mid-Atlantic states, Pennsylvania, Delaware, Virginia, West Virginia and Maryland, the federal agencies involved in the development or regulatory review of transportation projects collaborated in 1992 to integrate the NEPA and Clean Water Act Section 404 permit processes into a single, formal and streamlined process (U.S. Environmental Protection Agency et al. 1997). These agencies involved are the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Federal Highway Administration. This effort was undertaken in part because many of the requirements for NEPA compliance are similar to those for Section 404 permits required for fill proposed to be discharged into waters of the United States, including wetlands. Compliance with Section 404 requires a review of purpose and need, assessment of environmental impacts, a thorough evaluation of alternatives, and participation by the public and interested parties. The integrated NEPA/Section 404 Process has been so successful that it is being applied to nearly all large transportation projects within those five Mid-Atlantic states.

Prior to the development of this integrated process, transportation projects that required an Environmental Impact Statement (EIS) and a Section 404 permit issued by the U.S. Army Corps of Engineers typically proceeded through the respective regulatory processes in a sequential fashion. For these large transportation projects, the EIS and Record of Decision were often completed prior to the formal start of the regulatory review process for the Section 404. These sequential processes resulted in protracted project reviews, duplicative efforts, additional expense for the project proponent, and frequently, Section 404-related changes to the project that had already cleared the EIS process.

The integrated NEPA/404 process includes provisions for compliance with Section 7 of the Endangered Species Act, Section 106 of the National Historic Preservation Act, and Section 4(f) of the U.S. Department of Transportation Act of 1966 as well as provisions for dispute resolution through Sections 404(q) and 404(c) of the Clean Water Act and NEPA referrals to the Council on Environmental Quality. That process was further refined in January, 2000 to support the Transportation Equity Act for the 21st Century (commonly referred to as TEA-21) and became known as the Mid-Atlantic Regional Environmental Streamlining Process (Mid-Atlantic Transportation and Environmental Task Force 2000).

This integrated process contains formal concurrence points as part of the sequence of steps that comprise the process. There is a concurrence point at each of three critical steps in the process: (1) Project Level Purpose and Need; (2) Alternatives Carried Forward (for detailed consideration); and (3) Preferred Alternative and Conceptual Mitigation Plan. At each concurrence point, participating agencies are required within 30 days to provide a written determination that information to date is adequate to agree that the project can be advanced to the next stage of project development. The action agency in this process, typically the Federal Highways Administration along with the state transportation agency, can proceed beyond a concurrence point for which full concurrence has not yet been achieved but does so at its own risk in terms of expenditures of time and resources.

Upon providing concurrence, each agency agrees not to revisit previous process steps unless conditions change. Agencies that do not concur must provide a detailed explanation of why concurrence cannot be provided. Non-concurrence initiates the conflict resolution process, which is designed to resolve conflicts quickly and efficiently and at the lowest possible level within the hierarchies of the agencies involved.

The steps of the integrated process are condensed in the following table and are presented as a general framework for a streamlined NEPA/Section 404 process that fully engages the public and relevant agencies, and that facilitates timely, cost-effective, and environmentally sound decisions. For purposes of clarity, the steps listed in the Integrated NEPA/404 Implementation Guide for Transportation Projects (Figure 3) (U.S. Environmental Protection Agency et al.1997) are emphasized rather than those of the more recent Mid-Atlantic

Regional Environmental Streamlining Process (Mid-Atlantic Transportation and Environmental Task Force 2000). A complete understanding of the principles and steps of the process requires a review of both documents.

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Is There Integration of Natural and Cultural Resources in the NEPA Process?

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Cultural resources are a substantially misunderstood and isolated aspect of the National Environmental Policy Act (NEPA). Although some progress has occurred, the last 30 years of NEPA implementation provide reasons to be concerned about the relationship between cultural resources and NEPA's past, present and future. Do we have a federal law that adequately ensures the government . . . *preserve*[s] *important historic*, *cultural*, and natural *aspects of our national heritage*. . . (italics emphasized, NEPA, Section 101(b))? In this presentation I will argue an *integrated approach* toward cultural and natural resources is lacking in the NEPA process. First, I will define cultural resources and discuss related topics. Next, I will identify other laws applicable to cultural resources and covered by NEPA. In keeping with this symposium, I then will offer my interpretation of NEPA and cultural resources under the categories of the Good, Bad and Ugly, in reverse order with emphasis on trying to understand *why* an integrated approach rarely seems evident.

What are Cultural Resources?

Many of us are at least vaguely familiar with the term "cultural resources." If not, you are probably *not* involved much in federal undertakings or environmental studies related to physical resources. King and Rafuse (1994:8) indicate "there is no inclusive, broadly understood definition of the cultural environment" under NEPA (an important problem I later will comment on additionally). For purposes of a simple definition, let's say cultural resources are empirically measurable aspects of human culture. To break it down, "culture" can be defined as "a system of behaviors, values, ideologies, and social arrangements ... [that] help humans interpret their universe as well as deal with features of their environments, natural and social." (King 1995). "Resources," in essence, are something that's certainly or potentially "useful to someone" (King 1995), and while

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1 Views presented are those of the author. They do not necessarily reflect policy, practices or doctrine of the U.S. Army Corps of Engineers.

we tend to think of this in material terms (i.e., food, shelter, etc.), we also know there are less tangible elements of "resources" humans depend on (e.g. spoken language). The more specific working definition for cultural resources under NEPA is generally either (1) "historic properties" as defined under the National Historic Preservation Act (see below), or (2) socio-economic and social factors. "Historic properties" are physical evidence of human culture ranging from portable objects to, more typically, complex, fixed-in-place physical manifestations, such as historic buildings or archeological deposits, with known or potential "significance" as defined by criteria applied from the Department of Interior's National Register of Historic Places (36 CFR 60, 36 CFR 63, Butler 1987). King (1998:125-128) indicates that regarding socio-economic and social studies, the approach of Social Impact Assessments (SIAs) has shifted away from social and cultural impacts to become a quantified presentation on demography, employment and economics. King (1998, 1995) has persuasively shown that archeologists have promoted the term "cultural resources" to be applied under NEPA to focus on the "historic properties" perspective with an emphasis on archeological deposits and, to a lesser degree, historic structures architectural in nature.

What are the Major Cultural Resources Laws Associated with NEPA?

A number of federal laws other than NEPA pertain to cultural resources and should be considered when implementing NEPA. Many of you are probably familiar with the names of these laws. I will very briefly identify and comment on some below. What you thought you knew even a few years ago about a particular cultural resource law may not be what legally exists today.

The National Historic Preservation Act (NHPA) (16 USC 470 et seq.) is the key federal statute for cultural resources. The NHPA also is directly linked to NEPA (both laws were enacted within three years of each other) (King 1998: 123-127). In essence, the NHPA establishes a federal policy for "leadership in preserving, restoring and maintaining the historic and cultural environment of the Nation" (U.S. Army Corps of Engineers 1996). It covers "Historic Properties" which are listed in or eligible for listing in the National Register of Historic Places (NRHP, established under the NHPA). If a Federal undertaking may affect historic properties, Section 106 of the NHPA requires the lead (or designated) agency to identify historic properties, if such are present, assess effects, and resolve adverse effects (Advisory Council on Historic Places 2000a). Section 110 of the NHPA (National Parks Service 1998) established a program to locate, inventory and nominate all NRHP-eligible historic properties under the respective federal agency's ownership or control (U.S. Army Corps of Engineers 1996). The NHPA regulations "Protection of Historic Properties" (effective June 17, 1999) (Advisory Council on Historic Places 2000b) specifically addresses the relationship of NHPA and NEPA. This recently revised regulation now provides for an improved process where federal agencies can use preparation of an Environmental Assessment (EA) or Environmental Impact Statement (EIS) to comply with Section 106 of the NHPA (*see* 36 CFR 800.8).

The American Indian Religious Freedom Act (AIRFA) (42 USC, 1996) requires federal agencies to consult Native American, Eskimo, Aleut, and Native Hawaiian groups when federal actions might affect their freedom to believe, express and exercise traditional religions (U.S. Army Corps of Engineers 1996). Physical sites (often termed "sacred sites") are involved under AIRFA, but also there are the aspects of possession of portable materials and the *activities* of ceremonies and rites. The physical sites are considered under the NHPA (i.e., sacred sites may be listed in the NRHP). Cultural and religious practices of AIRFA should be addressed under NEPA despite the fact that many EISs do not mention AIRFA (King and Rafuse 1994: 12-13).

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 USC 3001 *et seq.*) is primarily a civil rights law that has directly and indirectly changed the way museums, archeologists, and others consult with Native Americans and Native Hawaiians. NAGPRA is best known for inventories and repatriations of human remains and associated materials related to existing collections associated with federal funding or federal lands. In very recent years, NAGPRA has shifted toward consultation where known or potential Native American/Native Hawaiian human remains and/or associated materials become newly identified on federal or tribal lands, or come into federal possession. NAGPRA can apply under NEPA when studies conducted for NEPA purposes (field surveys and excavation) reveal human remains or "Native American cultural items" (King 1998). As importantly, NAGPRA is symbolic of our nation's continuing efforts in resolving social issues related to justice and acculturation. In that manner it relates to recent Executive Orders and agency policy statements giving Native Americans a more equitable role in consultation, including that involving NEPA (*see* Executive Order 13084, Consultation and Coordination with Indian Tribal Governments, May 14, 1998; Memorandum "Government-to-Government Relations with Native American Tribal Governments" April 29, 1994, President William Clinton; and Executive Order 12898). In a practical if not legal sense, it already is clear that NAGPRA and the political atmosphere associated with NAGPRA are changing the way cultural resources consultation takes place under both NHPA and NEPA.

The Abandoned Shipwreck Act (43 USC 2101-2106), a 1987 statute (U.S. Army Corps of Engineers 1996), provides that the federal government asserts ownership of abandoned shipwrecks in State waters and submerged lands (lands beneath navigable waters) (*see* Submerged Lands Act, Section 2 [43 USWC 1301]). The federal government may transfer ownership of abandoned shipwrecks to the pertinent State entity who owns the submerged lands. However, shipwrecks that were originally federal property (such as military craft or historic Union watercraft from the Civil War) remain federal property. Also, Civil War-era *Confederate* shipwrecks are considered property of the U.S. Government. NEPA studies along with compliance actions related to the NHPA can cause these submerged resources to become identified, and involve specific consultation with State government and other parties. Relic collectors/salvors may become interested in pursuing destructive (and potentially unlawful) actions when these resources become identified as a result of NEPA and NHPA studies.

The Archeological Resources Protection Act (ARPA) (16 USC 470 *et seq.*) is largely directed at protecting cultural resources on federal and tribal lands (U.S. Army Corps of Engineers 1996). If a NEPA study includes such lands, a permit under ARPA may be necessary to conduct archeological investigations. NEPA-related activities must not stimulate public interest in specific cultural resources sites (on federal or tribal lands) to the point such resources become endangered by unlawful removal of artifacts, vandalism, etc. This might, for example, come through NEPA Scoping communications, EIS distribution, or later as an unanticipated indirect effect from an implemented project.

In summary, while the NHPA and ARPA protect historic properties, AIRFA protects Native American religious sites and practices, and the Federal Records Act addresses certain historical documents, *only* NEPA "provides a statutory basis for addressing and controlling impacts on the cultural environment in its entirety" (King and Rafuse 1994: 2).

In the interest of this conference's audience, I finally would like to make special mention of the recent National Wildlife Refuge System Improvement Act (P.L. 105-57, signed 9 October 1997). Among other important changes this amendment to the National Wildlife Refuge System Administration Act directs the Secretary of the Interior to propose comprehensive conservation plans for all National Wildlife Refuges (except for lands in Alaska), and these plans shall consider "archaeological and cultural values" (Bill Summary of H.R. 1420, P.L. 105-57, as revised and passed). An implementing regulation for this statute is not finalized but this new legal act likely will have substantial implications for NEPA studies involving National Wildlife Refuges. It will be interesting to see how cultural resources are addressed in these conservation plans.

The Bad

I consider "the Bad" for cultural resources and NEPA to be the most common, if not "normal," problems settled in over the last 30 years. It is appropriate I discuss this topic first as for that reason it may be the most important. The Bad involves plenty of *implicit*, rather than *explicit*, conditions that guide, effect or otherwise lurk as background assumptions in the NEPA process. Some of these "conditions" are no more than what could be called subconscious assumptions a project coordinator might bring to his/her individual approach to working with NEPA. These sometimes reflect very specific personal biases set early in one's life. For example, my spouse was raised in suburbs of Philadelphia and I grew up on a farm in Central Texas. I can assure you that certain values we bring to what we do in life were influenced by our respective "cultures of origin," and have been known to clash. Other "conditions" reflect theoretical baggage NEPA professionals accumulate later in life, from respective academic disciplines. What I am saying is that we have an interesting burden—culture is both partly *what* we're studying under NEPA, and what is *shaping us* as we study it.

At any rate, although I earlier presented a working definition of cultural resources, now I will tell you the Bad Truth. As King (1998) points out, "cultural aspects of the environment have been implicitly defined—quite inadvertently—by NEPA practice and practitioners in such a way as to make such values effectively invisible to environmental analysis." In essence, there was a prominent drift during the last 30 years toward letting archeologists emphasize prehistoric, typically American Indian, archeological deposits (and NEPA-related study of existing records specific to archeological sites) as the *key* focus for NEPA where cultural resources were concerned. I think this was supported by natural resources professionals who either (1) found themselves, especially in the early years of NEPA, delegated "to handle" the cultural resources section of a NEPA study, or (2) preferred to work in a vacuum where cultural resources were concerned: "let the archeologist(s) take care of that section, I have plenty to do with the plants, animals, water quality, etc. Plug in what works and let's move on, we can avoid, dig up to mitigate, or deal with the archeological sites later down the road."

King (1998), an archeologist himself, argues that somewhere along the way we lost the notion of looking at other cultural values that relate to the natural environment, the human environment, and the actual intent of NEPA. He pointed out that, by the 1970s, archeologists created the term "cultural resources management" (in contrast to the existing term "natural resources management") (King 1995). He believed this discouraged an integrated approach toward all cultural issues, not to mention natural resources. To further confuse things, the terms "Archaeological Resource Management" (Knudson 1982) and "Applied Archaeology" (Wendorf 1979) have been used for essentially the same functional definition as "cultural resources management."

So here we are with a working definition of cultural resources primarily archeological in nature. Archeologists may be the Bad Guys more so than the biologists (or natural scientists). This is because from our time as Anthropology students in graduate school, we literally torture ourselves with understanding an explicit theoretical perspective. We generally have minimal amounts of physical data with thousands of years of post-depositional effects. Scientific and cultural methodology, and a well-interpreted *natural* context across time and space, is made *very* explicit prior to interpreting and presenting information. This relatively young scientific discipline (Fagan 1996) has been quick to incorporate the use of biology (including physical anthropology for both human and animal remains, paleobotany, and ecology and human behavior [e.g., Broughton and O'Connell 1999]), geo-sciences (geology, geomorphology, geography, etc.), statistics (particularly sampling methodology and interpretation), philosophy of science (*see* VanPool and VanPool 1999) for an example of how archeologists ponder the relationship of nature and science), chemistry (dating techniques), etc. Biologists, on the other hand, perhaps are more comfortable to be in what they see as a "hard science" and are busy analyzing substantial amounts of "real data." Do biologists sit around fretting about whether their profession is a puppet of *instrumentalism* (e.g., Plumwood 1995)—the idea "that nature possesses no inherent worth except that which directly benefits humans" (Cockrell 1999:68)? Anthropologists (including archeologists) ponder such topics. Indeed, do any NEPA coordinators utilize explicit definitions for terms like "natural" (as in "restoration of natural systems" or "natural heritage"), wilderness, wildlands, ecosystem approach, or landscape ecology (e.g., Clark 1999). If so, is the component of human culture, physically and non-physically present in these "natural" contexts, addressed? Do natural resources professionals working with NEPA question specifics of culture's role in the plant, animal and geophysical world? I do know professional archeologists, as anthropologists, ponder topics such as sociobiology (Wilson 2000). You will even see archeologists consider the wildlife management *principle of edges* (Rhoades 1978).

The problem of Bad definitions (including no definitions) may be a broader aspect of the complexity of understanding the environment in an adequately descriptive and comprehensive way, as NEPA would have us do. The Council on Environmental Quality stated at the 25-year mark "many agencies with large holdings do not know the extent or location of archeological sites, wetlands, or other important environmental features (Council on Environmental Quality 1997). As a result is it any surprise our categories of environmental interest are *poorly* defined, or interpreted? For example, NEPA states we should "preserve important historic, cultural and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity and variety of individual choice" (NEPA Section 101[b]), but when was the last time you saw a NEPA-associated analysis use information drawn from cultural resources, socioeconomic analysis and natural resources to promote *interpreting* cultural diversity and heritage topics?

A final series of the Bad specific to cultural resources includes three considerations. First, the scale of many NEPA studies is such that it is impossible to fully inventory the baseline information on the physical manifestation of cultural resources sites. That is, the time and funds are rarely adequate for full field surveys and evaluation. For large areas, reliance is made on existing records (often minimal) and reconnaissance-level field inspections. Phasing in full inventory of cultural resources sites is allowed under NEPA and the NHPA, but even with formal agreements among consulting parties the cultural sites may suffer adverse effects never identified at the time of the EIS study. In some cases the Bad (leading to Ugly) is that planners may hesitate to openly identify the *substantial additional* planning costs required for cultural resources. Second, I point out that in my experience the Area of Potential Effect (APE) for cultural resources sites may have different boundaries compared to the APE of other resources categories (fish habitat or wetlands, for example). Cultural resources APEs rarely are explicitly addressed, especially in terms of maps that show clear boundaries. This can cause management and operation problems later in the project's life, which leads to my final point of the Bad. While monitoring of effects on natural resources is a common technique for natural resources mitigation, cultural resources sites seldom receive adequate monitoring for both short-term and long-term effects linked to NEPA study. I think the blame here lies mainly with public service archeologists who have been fixed on the "excavate to mitigate" philosophy (another "procedural relic" of the 1970s) that offers little thought for what happens to remnants of mitigated archeological sites, or sites believed to be protected through avoidance.

I have tried to portray that the first and most basic Bad is that we don't have adequate definitions to guide us regarding cultural resources. This leads to a disintegrated approach to cultural and natural resources under NEPA. Archeologists have encouraged this drift. All of us need to be thoughtful and explicit about where we come from in our respective professional disciplines, and what we have in common.

The Ugly (You-gly)

Down in South Texas we used to have two expressions for the term "ugly." One was the common "ugly" in terms of Bad as discussed above. And then you had the really ugly which is pronounced "You-gly," where I am now in this presentation. The worst case of You-gly is when professionals knowingly prefer to work in their respective professional vacuum. This is true if one is considering biologists, archeologists, engineers, or whatever technical profession one may be founded in. Folks, we know the year 2000 and modern society have an overriding theme—the old days of being comfortable in one narrow slot are long gone, and probably never to return. I know, from personal experience, there are resource professionals out there who consciously work in a limited, narrow view of NEPA reality, and prefer this. Perhaps they have given up on the system and shrug off that they have only X more years until retirement and the nagging idea will go away that a meaningful integrated approach under NEPA might be possible. That, to me, is the ugliest of the Ugly.

Now, for the purposes of giving You-gly topics the benefit of a doubt (and being respectful while we're generalizing) let's say most of the problem is really that of *subconsciously* not wanting to incorporate information from outside-the-box one spent so many years gaining access to, *because* the new information just doesn't seem to fit easily anywhere. Professional stereotyping comes in here. Sometimes I feel much of my career has been spent explaining to people "No, the purpose of cultural resources studies is not to do professional arrowhead-hunting." I'm sure we have all said at one time or another, "He/she is a biologist, archeologist, or [pick any profession], what the heck are *they* doing at this meeting" At any rate, here is reality. When researching for today's presentation, one of the first references I checked was "The National Environmental Policy Act, A Study of Its Effectiveness After Twenty-five Years" (Council on Environmental Quality 1997). Being a good specialist, I went straight for the section(s) that might focus on cultural resources. There weren't any. However, a major section on an Interdisciplinary approach exists (Council on Environmental Quality 1997: 25-29) and surely there would be something there. "Economic and social factors" (Council on Environmental Quality 1997: 25) were identified here but there seems (to me) to be the usual implicit perspective that the terms "environmental" and "ecological" are a *natural* resources perspective that drives the process. Elsewhere, in one appendix (Council on Environmental Quality 1997) a final "cluster of study participants" is listed as "state, local and tribal governments" (Council on Environmental Quality 1997: 44). This appendix notes that tribal governments contacted recommended "training of [Federal] agency staff in tribal governance and cultural resource matters"

(Council on Environmental Quality 1997: 44). Another appendix (Council on Environmental Quality 1997: Appendix C) listed King and Rafuse (1994) under "Key Documents Created for this Study" (Council on Environmental Quality 1997: 45). However, upon reading King and Rafuse (1994) I could not see where their study's input was reflected in the CEQ report.

I must comment on something related to the above that ought to be relegated to the academic trash heap by now, apparently has not been, and I need to dignify it with a comment. I am speaking of the concept that as one is in the early stages of what may come to be a NEPA-related career, there is an imprinting from respective academic programs and professional experience. This imprinting has, traditionally, shuffled one off into one of two categories often called *hard* science and *soft* science (i.e., the later being social sciences, or anything with the word "cultural" associated) (King 1998). I thought science was science, but there are professionals who continue to view the world in the narrow-slots of whatever is meant by "hard" (read "real") science versus "soft" (read "pseudo") science, and act accordingly. To gain personal, professional credibility in the realm of biology, archeology or whatever, one literally goes through what could be termed journey-man training similar to that utilized by the European guilds of the Middle Ages. I believe (and hope) that with today's merging, technology-driven information analysis and comprehensive approaches to research, this is a You-gly problem that eventually will go away. Unfortunately, governmental job descriptions continue to put us into specialist labels and job descriptions while our "real world" duties are very much generalist-oriented (or should be) to be successful at working with NEPA.

Finally, I'll mention a case of You-gly we cultural resources specialists have been accused of, implicitly or otherwise, over the last 30 years regarding NEPA. This is a You-gly on the way out but still in need of commenting on. Each year millions of dollars in public money (and some non-federal funding sources) required for NEPA and NHPA compliance are directed towards cultural resources studies across the United States. This is because in most cases even with existing records for a particular area, we simply don't know what's out there in the dirt, and archeological field studies with even limited sampling are expensive. Back in the early days of NEPA, the first generation of public service archeologists associated with the boom often were based with archeological programs affiliated with colleges or universities. These programs generally never were intended to be more than research-oriented, non-profit groups that provided a "salvage" effort linked to massive government projects from times *prior* to NEPA. After the passing of NEPA, the NHPA, and other laws such as the Moss-Bennett Act (Historical and Archeological Data Preservation [16 USC 469 *et seq.*], USACE 1996) academic field archeologists came under the pleasant burden of being pressed to conduct large scale projects with ready funding and legal support on a scale never before offered. Where they were once the "poor cousins" begging to conduct a little salvage as large public projects were built, both the academic programs and the persons handling cultural resources/environmental compliance at lead federal agencies suddenly found they needed to throw a lot of people (and money) on environmental planning efforts to keep government-funded or permitted projects on schedule and in compliance. The support services of the university groups exploded with activity, and along the way it appeared to some observers (including natural resources professionals) that agency cultural resources staff (i.e., archeologists) were feeding their colleagues in academia funds and research in a system few outside the technical specialization could question. Even today, literally 30 years later, I find this perception (and suspicion) continues. The sad part of this You-gly is that there likely was truth within the context of those times (Wendorf 1979), while today there has been a shift to private consulting firms working as businesses to seek the "bottom-line" for agency needs. Public service agency archeologists are acutely aware of keeping costs and schedules under control. At any rate, I will remind you there is *not* a conspiracy for [name-an-agency] archeologists to feed pure research for buddies back at the university. The fact is we are absorbed in fighting (and selectively, at that) the "brush fires" of compliance for unavoidable impacts to cultural resources. It is laughable to think anybody is sitting at their desk, dreaming up ways to spend thousands to do research for research sake's.

The Good

Now is the pleasant part of my presentation. Despite my previous comments, there are some positive trends bringing cultural resources and natural resources topics, under NEPA, a lot closer to a holistic approach. First, and very important, is that I am at this symposium today. This is proof enough we are talking to each other, and interested in the "big picture." A second positive factor I think is that we are, indeed, in a time of substantial change. Someday we may look back at this turn of the century to see it to be as important a "time marker" as anything the 1960s produced. We all recognize this change is underway at levels affecting our workplace and our personal beliefs about what is important and not so important concerning "what we do" as resource professionals. Electronic communications technology, of course, is a part of this. GIS is changing the way we analyze environmental baseline information and it encourages an integrated approach to all resources that can be physically described cultural or natural. I think times of change such as we are in usually bring, on the whole, improvements. Another example, I think, of how technology is improving and integrating the NEPA process, is reflected by the incipient use of the Internet in the NEPA Scoping process. An excellent example of this can be found with a web site offered by the U.S. Air Force's Dugway Proving Ground, Utah (main web site *http://www.dugway.army.mil* and EIS at *http://140.196.6.21/eis/default.htm*).

On a more personal basis, I would like to close with an example I feel is reflective of the positive direction we are headed as resources professionals working cooperatively. In the last few years, and despite being labeled a "Federal archeologist" I have become involved with broader aspects of NEPA coordination. Although 20 to 30 years ago biologists could do cultural resources compliance, I don't think the same was necessarily true in reverse. My supervisor (a biologist by training) has demonstrated a progressive approach to integrated resources study by allowing me to work with NEPA coordination outside cultural resources. Regardless, I became involved with a complex NEPA project in Arkansas where major national wildlife refuges exist. When I first contacted one refuge manager, expecting to get a long pause when I explained my professional background, I was pleasantly surprised he quickly expressed that my involvement with the project was positive from his perspective, and he had some cultural resources issues for which he was glad I would be involved. This kind of response might not have been the case a number of years ago. I was never more pleased there is, indeed, perhaps a trend toward viewing cultural and natural resources management as an integrated effort.

Summary

Overall, the answer to my title is: "No, we still have a long way to go." On the positive side, we are indeed in a time of change and there is some evidence of a shift to a more integrated approach. I have frequently Dr. Thomas King a lot in this presentation. He is, indeed, a leader in the explicit discussion of cultural resources issues including environmental resources and public policy. In that manner, I would like to end with yet another quote from him: "The transmission of knowledge down the generations is at the very heart of human culture, and culture defines substantially how we view and value the environment" (King 1998: 118), and I would add, *how we view the cultural <u>and natural</u> environment, in an <u>integrated</u> perspective.*

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NEPA Ratings: What Have We Learned?

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In the United States, the National Environmental Policy Act (NEPA) requires preparation of an environmental impact statement (EIS) when there is a potential for significant environmental impact by a major federal action. Preparation of these documents is a task taken seriously by federal agencies. At every Environmental Protection Agency (EPA) Regional Office there are at least one to two full-time employees working on NEPA along with staff members at EPA headquarters. This does not include the contractor staff that supports EPA or the multitudes of government employees and contractors preparing draft environmental impact statements (DEISs) across the country.

When a DEIS is completed, the EPA reviews it and provides comments in the Federal Registrar, as required under Section 309 of the Clean Air Act. To achieve this mandate, EPA has created an environmental review process that uses two scales to evaluate DEIS. One is a four point rating scale that evaluates the environmental impact of the proposed action. The categories include: lack of objections (LO); environmental concerns (EC); environmental objections (EO); and environmentally unsatisfactory (EU) (see Table 1). Specifically, the evaluation is based on impact of the preferred alternative on the environment (EPA 1984). The other scale is a three-point scale that categorizes the adequacy of information presented in the DEIS. The information categories include adequate, insufficient information and inadequate (see Table 2).

Both of these evaluations primarily take place at the ten EPA regional offices throughout the U.S. with little input from the EPA headquarters office in Washington, D.C., unless the document rates either in an unsatisfactory or inadequate category. The comment process takes no longer than 45 days from the start of the official public review period, unless there is an extraordinary situation that warrants longer reviews.

Using both of the scales, this research investigates if the ratings of DEIS have improved over time? Preparers of a DEIS are expected to become better at understanding how to design proposed actions that achieve preferred alternatives with less environmental impact. While the referred alternative is not necessarily the best environmental option, over time there should be less negative ratings of preferred alternatives due to a better understanding of how to incorporate the NEPA process into federal projects through mitigation techniques

Table 1. Rating the environmental impact of the preferred alternative.[a]

LO = Lack of Objections—The review has not identified any potential environmental impacts requiring substantive changes to the preferred alternative. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposed action.
EC = Environmental Concerns—The review has identified environmental impacts that should be avoided in order to protect the environment fully. Corrective measures may require changes to the preferred alternative or application of mitigation measurer that can reduce the environmental impact.
EO = Environmental Objections—The review has identified significant environmental impacts that should be avoided to adequately protect the environment. Corrective measures may require substantial changes to the preferred alternative.
EU = Environmental Unsatisfactory—The review has identified adverse environmental impacts that are of sufficient magnitude that EPA believes the proposed action must not proceed as proposed. EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment.

[a] Adapted from EPA, Policy and Procedure for the Review of Federal Actions Impacting the Environment, October 3, 1984 and EPA, Review of Federal Actions Impacting the Environment, Chapter 3, Preparation, Approval, and Distribution of Comments on Federal Actions, March 1,1975.

and prevention. Since projects may be more complex due to technology, it may not be feasible to have an increase in the top rating (LO) for DEIS. However, we expect some stabilization in this top rating (LO) over time since agencies should have benefitted from years of NEPA preparation and implementation. And it is certainly reasonable to expect that there would be less of the extremely negative ratings, such as EU or EO.

However, the expectation for the information rating is opposite of the preferred alternative rating. The scale that rates the adequacy of information presented in the document serves as a pseudo-measure of document preparation quality. It is labeled a pseudo-measure because it does not reflect effectiveness or efficiency of the DEIS impact on protecting the environment. For instance, the document could be rated with the highest category yet have a negative impact on the environment. Nonetheless, this rating does reflect an important aspect of NEPA that hinges to some extent on informing decision makers and the public of potential environmental impacts. Thus, information plays a key role in NEPA, especially for DEIS, thus making this rating a measure of document quality. It is anticipated that information adequacy will significantly improve due to enhancements in computer technology and the accessibility of obtaining information. In addition, increased knowledge and learning by agencies preparing these documents should have resulted in better information quality of DEIS. Information is not only easier and faster to acquire and access,

Table 2. Rating the information of the DEIS.[a]

Adequate—The DEIS adequately sets forth the environmental impacts of the preferred alternative and those of other alternatives reasonably available to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.
Insufficient Information—The DEIS does not contain sufficient information to fully assess environmental impacts that should be avoided in order to protect the environment fully, or the reviewer has identified new, reasonably available alternatives that are within the spectrum of alternatives analyzed in the DEIS, which could reduce the environmental impacts of the proposal. The identified additional information, data, analyses or discussion should be included in the final EIS.
Inadequate—The DEIS does not adequately assess the potentially significant environmental impacts of the proposal, or the reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analyzed in the DEIS, which should be analyzed in order to reduce the potentially significant environmental magnitude that they should have full public review at a draft stage. This rating indicates EPA's belief that the DEIS does not meet the purposes of NEPA and/or Section 309 review and, thus, should be formally revised and made available for public comment in a supplemental or revised DEIS.

[a] Adapted from EPA, Policy and Procedure for the Review of Federal Actions Impacting the Environment, October 3,1984 and EPA, Review of Federal Actions Impacting the Environment, Chapter 3, Preparation, Approval, and Distribution of Comments on Federal Actions, March 1,1975.

there is a large number of documents to use as sources of methodological approaches for the analyses performed in the past DEIS. In other words, information adequacy is the one area of NEPA that is expected to provide benefits of experience, expertise and computer technology, which all contribute to the preparation of better DEIS regarding the use of information. Therefore, it is expected that there will be more adequate information ratings and less inadequate ratings.

Another supporting reason to why both ratings should be less negative is EPA's requirement since 1984 to have meetings with agencies who receive negative ratings in order to improve the document before the rating process is completed. During the Clinton Administration, EPA has expressed desire to become more of a partner with the preparing agency during the DEIS process instead of rating the document without collaborative input. Both of these actions also lead us to believe ratings for both scales should either be improving or, at least, not getting worse over time.

The DEIS data base from EPA headquarters contains a total of 19,236 filed documents from 1970 to 1997 that were used to investigate these research questions. Also, to triangulate the results, interviews were conducted with the

EPA staff at headquarters and nine of the ten EPA region offices NEPA raters to understand in detail the trends of the empirical evidence. The findings suggest some interesting and unexpected results. First, it is more difficult today to receive a good rating from EPA than in previous decades. In addition, information quality of DEISs has decreased substantially even though there has been an increase in technology to access data, making more documents available to learn from when preparing the DEIS. This research identifies the trends and patterns demonstrated in the ratings and gives some potential reasons explaining how this can impact the NEPA decision-making process. The paper provides recommendations for NEPA practitioners and makes suggestions for continued monitoring of DEISs. Before analyzing the data, this paper examines why the EPA rating system is important to the NEPA process.

Why Rate Documents?

According to Caldwell (1998: xvi), "the purpose of NEPA is to write impact statements." Environmental impact analysis is thought by NEPA scholars and practitioners to be an important aspect of planning and policy determinations. Environmental impact analysis is a discovery function for ascertaining the range of risks and benefits of proposal that have major environmental consequences. To Caldwell (1998: xvii), environmental impact statements "have a disclosure function, democratizing the policy process and identifying alternatives to the proposed action." NEPA is case-specific and procedural, which is completely different than any other environmental law in the United States. In addition, NEPA is one of the few environmental laws that is not regulatory in nature. The enforcement action is not taken by a regulatory agency but implemented through litigation.

The intention of the original framers to require a DEIS is well documented by Lynton Caldwell who participated in the creation of NEPA and the DEIS with Senator Jackson (Caldwell 1995, 1997, 1998). The DEIS provision of NEPA resulted from a jurisdictional debate and ultimate compromise between Senator Muskie, Chair of the Air and Water Pollution Subcommittee of the Public Works Committee, and Senator Jackson, chief sponsor of NEPA and Chair of the Interior and Insular Affairs Committee. During the final negotiations of the NEPA legislation (Blaustein 1977, Caldwell 1998, Lindstrom 1997, McNollgast 1994), the environmental impact statement now known as DEIS was born. Senator Muskie wanted to ensure that NEPA would not impact his committee's jurisdiction of air and water standards so he agreed to a compromise. This compromise led to the requirement for a detailed statement, which required a discussion of alternatives and comments by other agencies.

For the most part, the focus on process has resulted since there is a lack of uniformity of method and sometimes a complete void of how to handle requirements for integration into DEIS analyses. For instance, today preparers of DEISs do not have a clear method for incorporating the recent mandates of environmental justice (Bass 1998) and cumulative impacts (Burris and Cantor 1997, Cantor and Kamath 1995). While the DEIS was never intended to be a scientific (Caldwell 1998, Caldwell 1982) or a one-size-fits-all document, it is sufficiently old enough now to have more systematic methods and definitions for preparers upon which to build. Caldwell (1998) fully addresses how more than science must be considered in an adequate environmental impact analysis. The over reliance on science and data collection, leaves many preparers of a DEIS surprised when the public questions the legitimacy of the document. However, several practitioners and scholars agree that there is a need for theory-building and systematizing some fundamental approaches (Lawrence 1997). The lack of uniform, accepted methods, especially in the social sciences, have become a problem in preparing and evaluating DEISs (Carpenter 1999). It requires the public to understand sophisticated analyses without the benefit of having a standard to use.

One result of not having clear guidelines for DEIS standards has been the role of the courts. Judicial review has clearly shaped the impact of NEPA, particularly DEIS preparation. Holland (1985) explained how the inconsistency of federal agencies to implement NEPA is partially a result of the courts not having been provided with a coherent definition of criteria for compliance with NEPA. Some agencies produce lengthy DEISs with a multitude of volumes while others adhere to the proposed 150 pages by CEQ (EPA 1999). One potential reason for such disparity is risk aversion to litigation. The reasoning being that by including more information and analyses agencies can protect themselves from adverse rulings by the courts.

Judicial decisions have emphasized the two major goals. The first is to provide the public with complete and accurate information about the significant environmental consequences of agency actions. The second is to ensure agencies give these environmental consequences appropriate consideration in their decision making process (Holland 1985). Generally, courts follow the procedural aspects of NEPA and defer any disputes about science and methodology to agency experts (Cardone 1990).

Ratings may be a way to address the lack of uniform standards for DEIS preparation and judicial review. Ratings could be developed as performance guidelines that improved the effectiveness of DEISs. Hickie and Wade (1998) developed such a scale and rated 14 environmental statements in Wales and the United Kingdom based on numerous content criteria. Recommendations for improvements in effectiveness and efficiency were made based on the detailed ratings. If a rating system was developed that incorporated the best methods and practices of analysis, then DEISs may be more useful to decision makers and the public. Currently, the rating system used by EPA is much more general and not very helpful to preparers of DEISs.

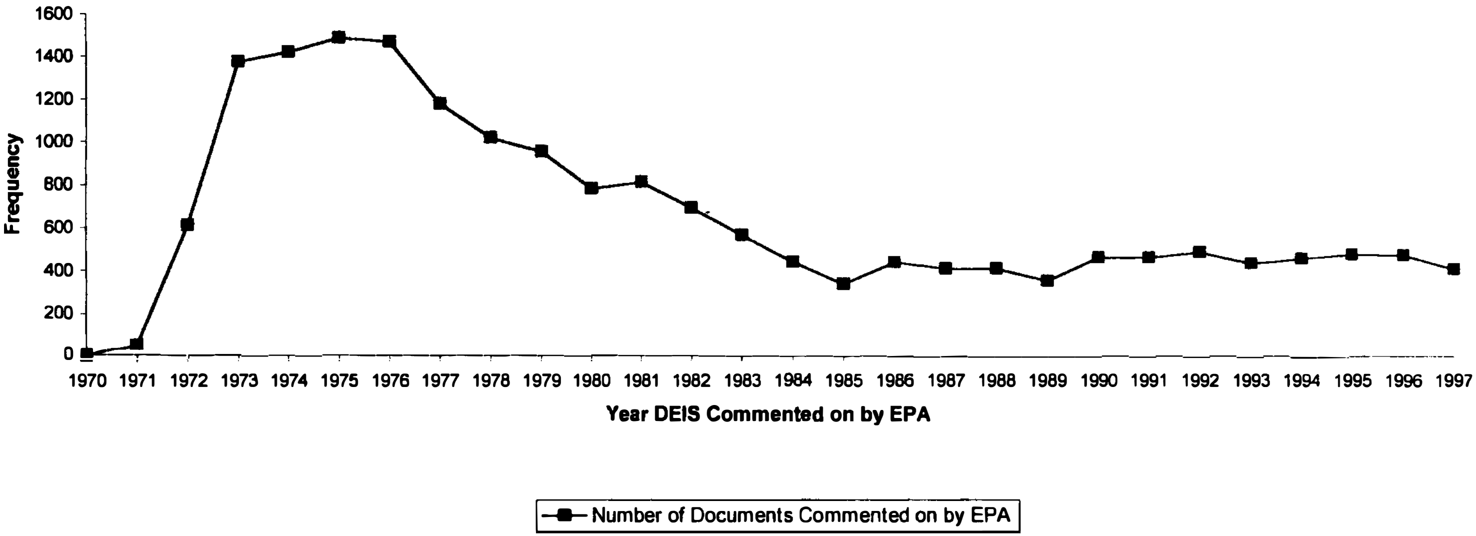
As cited in interviews, several of the EPA raters did not think the ratings really had much effect on the DEIS. Some commented on how often agencies accept ratings without concern for improving the document. A couple of the raters commented that the only rating that could have significant impact on improving the document was EU or inadequacy because of their threat of referral to CEQ and EPA headquarters. In fact, there is no real repercussion from receiving a negative rating such as EO or EC since the document is still acceptable. Thus, improving the ratings system used by EPA by making ratings tied to certain accepted standards for measuring impacts would be helpful.

DEIS Ratings

In general, the results illustrate how it is more difficult today than two decades ago to receive a top rating from EPA on a DEIS in both the impact of the preferred alternative and information. This was not the expected outcome for either scale. Figure 1 shows that most DEISs were commented on during the first decade of NEPA. In fact, half of all NEPA documents were filed before 1980. Beginning in 1977, the first sign of decline of preparing DEIS documents appears. That trend continues to decline until 1984 when there was some leveling of the number of documents rated per year. Today, about 300 to 400 documents are commented on by EPA annually. Solomon, Yonts-Shepard and Supulski (1997) speculate that more reliance on environmental assessments and categorical exclusions that avoid the DEISs process are reasons for this trend.

One aspect of not preparing more DEISs is decreased litigation. NEPA litigation when measured in number of judicial cases has decreased over time from 189 cases in 1974 to 106 in 1994. CEQ (1995) states that for the last 12 years the annual number of NEPA lawsuits has consistently been just above or below 100. However, the number of DEIS has also declined according to Figure 1. When using the ratio of litigation to documents filed, Solomon et al. (1997) found that there have been periodic increases of litigation when accounting for the decrease in documents. According to CEQ (1995), the most frequently cited basis for NEPA litigation has been the reliance on other options than the DEIS in NEPA. Because of the cost, time and effort in preparing DEISs, it is not surprising that agencies have sought other NEPA options in place of the DEIS.

Figure 1. DEIS commented on by Enivornmental Protection Agency over time.



Before examining the trends in the ratings, there are three important factors to consider when reviewing the DEIS data and drawing conclusions. The first factor is that the rating scale for the impact of the preferred alternative changed in 1984. EPA staff that worked in the NEPA office during this time discussed in their interviews why this occurred. EPA originally used a three-point scale that consisted of LO, environmental restrictions (ER) and EU ratings. EPA was satisfied with the LO and EU ratings but wanted more delineation in the middle category. NEPA staff claimed that there was a wide range of DEIS documents in the middle category that did not accurately reflect the quality of the documents. Therefore, EPA split the middle category in 1984 into two new categories called environmental concerns (EC) and environmental objections (EO). This allowed those documents just missing the LO mark to receive a different rating from those which were more objectionable or closer to a EU rating. All those interviewed who were around during the rating change expected that the data would indicate documents still received one of these two middle categories for ratings since LO and EU remained unchanged over time. To accommodate this change, LO and EU can be graphed over time, however, figures for ER and EC/EO will be reported in pre- and post-1984 timelines. Interestingly, the results show the opposite occurred in the rating change from what the EPA staff predicted.

The second factor to keep in mind is the change made in 1984 that linked the two ratings scales. Prior to 1984, a document theoretically could receive the top impact rating of LO and the lowest information rating of inadequate. EPA did not put restrictions on the combination of categories. However, starting in 1984, if any document received an LO, it's information rating could not possibly be inadequate. When NEPA staff was questioned about the impact of linking these two scales, they felt the ratings could be treated separately since documents were evaluated using these scales as independent ratings. Therefore, the scales are treated in this research as two separate ratings. EPA interviewees concurred with this approach.

The third factor to consider when drawing conclusions is the missing data. There is a large amount of missing data in EPA's data base. There were 19,236 DEISs commented on from 1970 to 1997. Of those cases filed, there were 9,121 DEISs in the database with ratings for the impact of the preferred alternative and 9,398 DEISs rated for information adequacy. Only 8,327 DEISs had data for both ratings. So, there is a large number of missing ratings. In defense of the data set, these are is all the data in existence at EPA. And, these are large samples remaining for both scales that aids in the analysis. However, the concern for biased data entry was investigated. The best methods of understanding if there is bias in the missing data not being reported was to ask the EPA staff and check for patterns within the missing ratings itself. Therefore, EPA staff was interviewed about this issue; the missing data were analyzed in detail checking for patterns of bias. All the EPA staff stated in their interviews that the missing data is a combination of lack of resources in the regions and, in some cases, lack of resources at EPA headquarters to import the data from the regions. The missing data problem continues today since there is no way for regions to directly enter their ratings into a national database. Letters from the regions are mailed to EPA headquarters and then entered manually into the computer by EPA headquarters staff. This process continues to produce missing data because updating the EPA headquarters data base takes lower priority over more important tasks. Thus, the missing values do appear to be random. There is no pattern when the missing ratings were analyzed by year, region, state or agency. EPA staff stated that there was no conscious decision to not report some cases over others and, in fact, they called the missing ratings random themselves. Thus, in this paper we have, with confidence, assumed the missing data to be random. In order to be more conservative and standardize our graphs, because of the large amount of missing data, we used the total percentage of documents per year in the denominator. This means we included documents where ratings were missing in order to not overstate the findings. Keep in mind that standardization is required because of the large difference in the number of documents commented on between the 1970s and later decades (See Figure 1). When the denominator was changed to the number of all-rated documents in the EPA headquarters data base (a lower number due to missing data), the patterns remained almost identical. Again, this gives us confidence that the trends are real, even with the large amounts of missing data.

Keeping these factors in mind, the results from the EPA ratings from 1970 to 1997 along with interviews from the NEPA staff are reported below.

The Decline of LO and the Stability of EU over Time

Two of the most important ratings for the impact of the preferred alternative are LO and EU ratings. LO is the top rating a DEIS can receive from EPA, and EU is the lowest. Table 3 shows the percentage of documents receiving ratings based on the total number of documents. This is considered the more conservative percentage because it includes the documents missing ratings. Titled "valid percentage" in the table, it is a percentage of DEISs based on the number of documents that have rating information (that is excluding the missing data). This second percentage will be larger, because of the exclusion of DEISs with missing ratings. The second percentage is important because it shows the same trends in a pronounced manner, which highlights these ratings trends. EPA records indicate that 4,934 documents received an LO rating, which is

Table 3. Preferred alternative ratings.

Ratings	Frequency	Percentage (includes missing data)	Valid percentage (excludes missing data)	Cumulative percentage
EU = Environmental Unsatisfactory	164	0.9	1.8	1.8
EO = Environmental Objections (only used after 1984)	455	204.0	5.0	6.8
EC = Environmental Concerns (only used after 1984)	1,680	8.7	18.4	25.2
ER = Environmental Restrictions (only used prior to 1984)	1,894	9.8	20.8	45.9
LO = Lack of Objections	4,934	25.6	54.1	100.0
Total rated DEIS	9,127	47.4	100.0	
Missing data	10,109	52.6		
Total DEIS	19,236	100.0		

approximately 25 percent of the total documents filed. Of the records that were rated and recorded, this is 54 percent of the DEISs ratings. Thus, LO is the largest rating category. The next largest rating categories are EC and ER, 1,380 and 1,894 respectively. EC accounts for 8.7 percent of the total documents (or 18.4 percent of those rated). ER accounts for 9.8 percent of the total documents and 20.8 percent of those rated. Only 455 DEISs received an EO, which is 2.4 percent (or 5 percent of those rated). EU had the lowest frequency of 164 documents, which is 0.9 percent (or 1.8 percent of those rated).

In interviews, the EPA staff made several interesting predictions about the rating trends. Interviewees thought there would be fewer EUs because of the administrative bias associated with the category. All EUs must be approved by EPA headquarters and often submitted to CEQ. Therefore, they thought that during the Reagan Administration who was known for trying to alleviate environmental requirements, that there would be less EUs. In addition, the interviewees thought that LOs would remain approximately the same for reasons stated previously that deal with a more cooperative partnering with EPA and learning by preparers of documents who should have gathered more expertise and experience in document preparation over time. However, the results show differently. Figures 2 and 3 show the trends of LOs and EUs percentages over time.

Figure 2. The decline of LO DEIS.

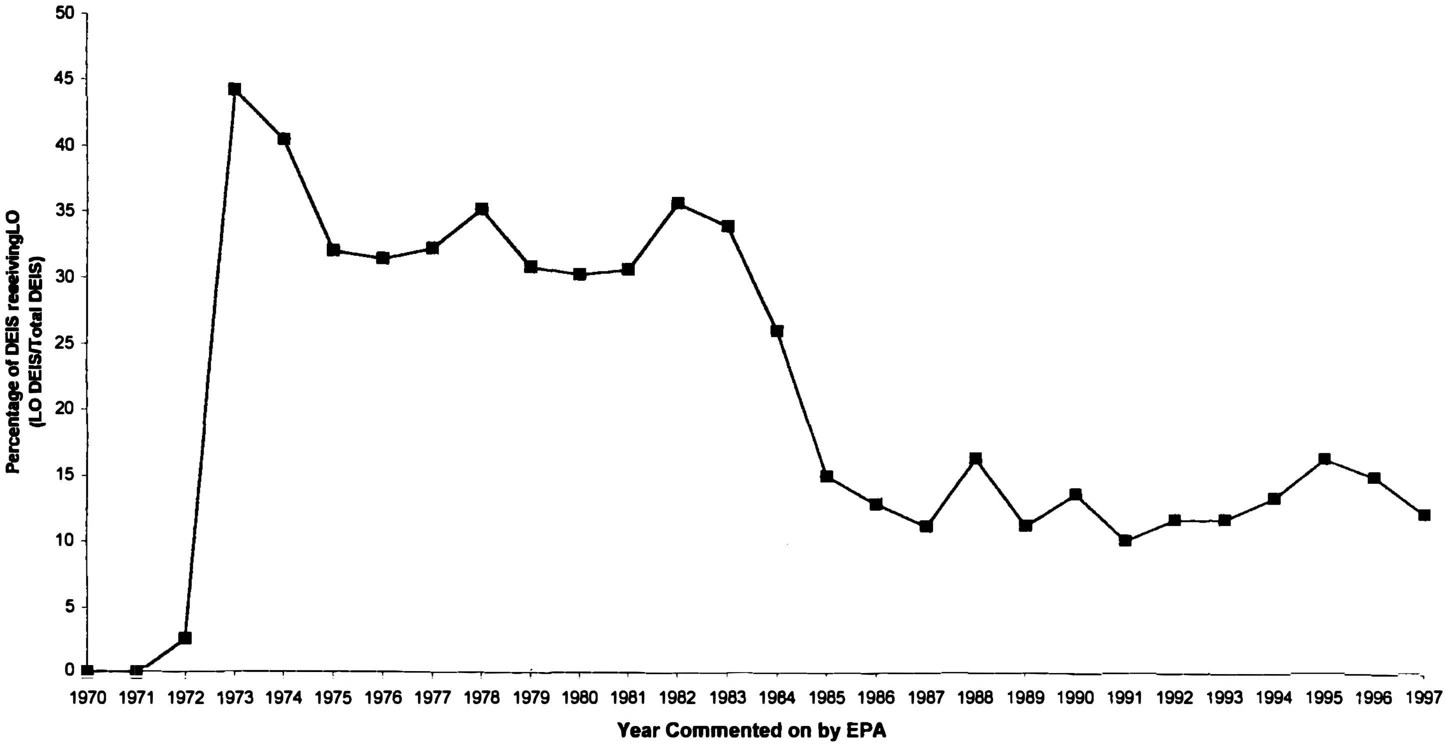
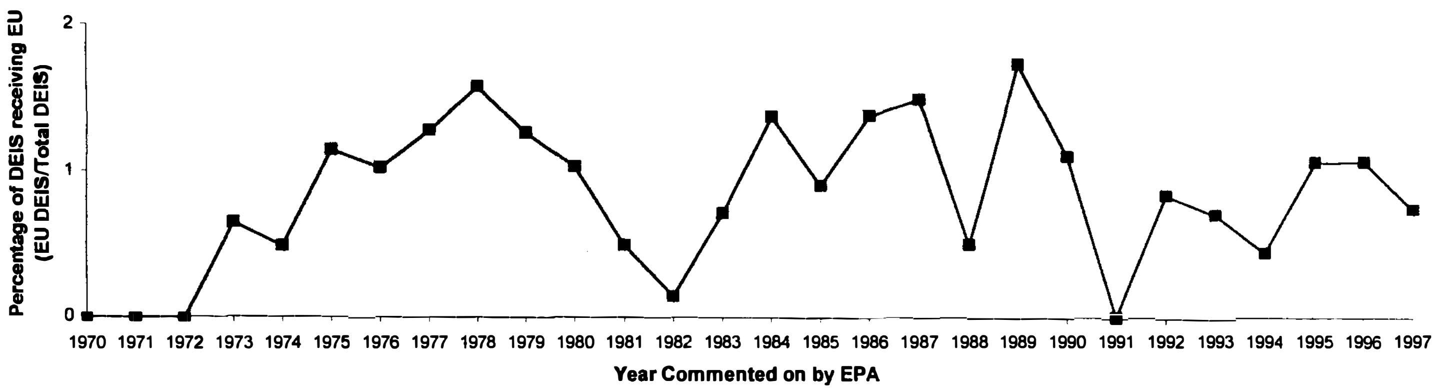


Figure 3. The stability of EU.



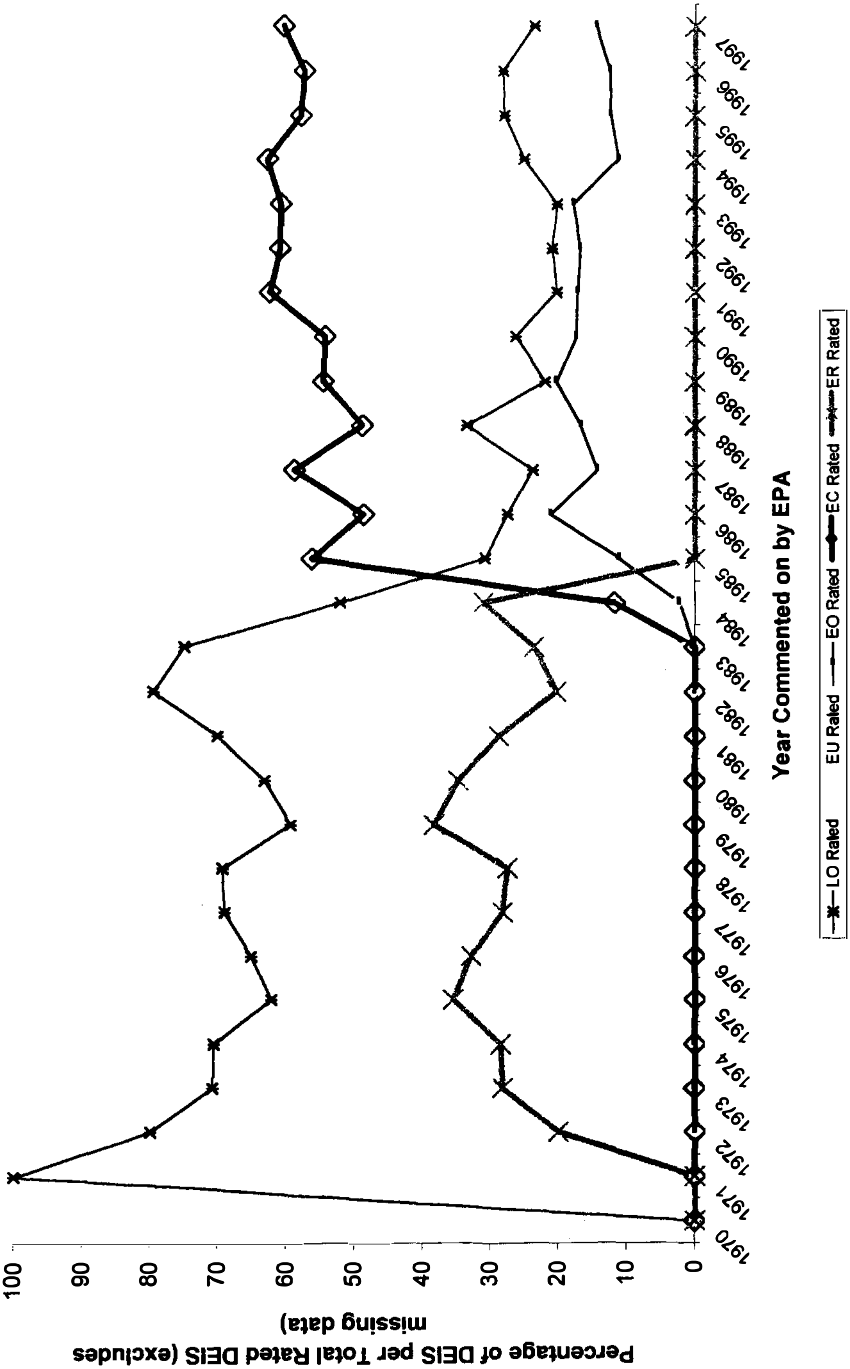
There was a significant and unexpected decline of LOs beginning in 1982 that has somewhat stabilized since 1984. The stability of having less LOs in later years (post-1984) may be accounted for in EPA raters actually being more reluctant to give out LOs. It appears raters relied more on the EC category after 1984. EC as a category sounds less negative than ER, which was the pre-1984 option. So, while a LO rating was not changed in procedures used by EPA raters, it clearly was impacted by the addition of the two middle categories—EC and EO. However, this does not explain the dramatic decline that begins after 1982 but prior to the 1984-scale change. One very plausible explanation was the reaction of EPA raters along with other EPA staff to the Reagan Administration appointment of Administrator Burford to the agency. This same reaction of EPA becoming more sensitive in enforcement actions during the Reagan Administration was documented in the hazardous waste and clean air programs by Wood (1990). LOs were solely controlled by civil servants in the regions who were out of the auspices of the ideological changes made to the agency. While resources were scarcer for NEPA raters during the Burford Administration, those documents that were rated were less likely to achieve the top rating. Clearly, the Reagan Administration did not have the impact of more documents getting top ratings of LO. Likewise, the number of documents being commented on was not explained by the Reagan Administration since the decline in documents began much earlier than 1981 when he took office. In sum, even today it is more likely that a DEIS will receive a rating other than LO when compared to previously years.

Like the unexpected results with LO, there were interesting trends in the EU data. Generally, very few documents receive EUs. The highest number of these documents occurred between 1977 and 1979, during the same time there was high number of LOs. Based on Figure 2, there is no impact from the Reagan Administration on EU ratings. If there were such an effect we would not see the modest decline in EU's in post-1983 ratings. EUs really have no significant patterns and tend to be a rather stabile rating over time of 1 to 2 percent of all documents. It appears like LO, the Reagan Administration had little impact on the actual numbers of EUs being given to documents. However, unlike LOs, DEISs are not anymore likely to receive a EU rating than in the previous decades of ratings.

Rating Changes in 1984: From ER to EC and EO

The last section demonstrated that there has been significant decline in LO ratings partially due to the rating change in 1984. There was no impact to EU ratings on the entrance of EO into the rating scale in 1984. However, there was an important trend in the middle categories that occurred with the rating change. First, Figure 4 shows that the EC rating eroded some of the LOs over time.

Figure 4. Ratings changes in 1984: from ER to EC and EO.



However, the new category of EO remains stabile over time and appears to closely track LO ratings. One explanation of this EO trend is that it has basically replaced the ER rating over time. A major conclusion from Figure 4 is that while environmental impacts of DEISs are not achieving the rating of LO, it is a positive sign for the environment that EC not EO dominates as the most frequent rating. Documents are not being rated the worst category of EU and are not achieving the top rating of LO, rather they are achieving the second highest rating of EC on a consistent basis.

DEIS Ratings of Information Adequacy

The Decline of Adequate, the Stability of Inadequate Ratings and the Rise of Insufficient Documents

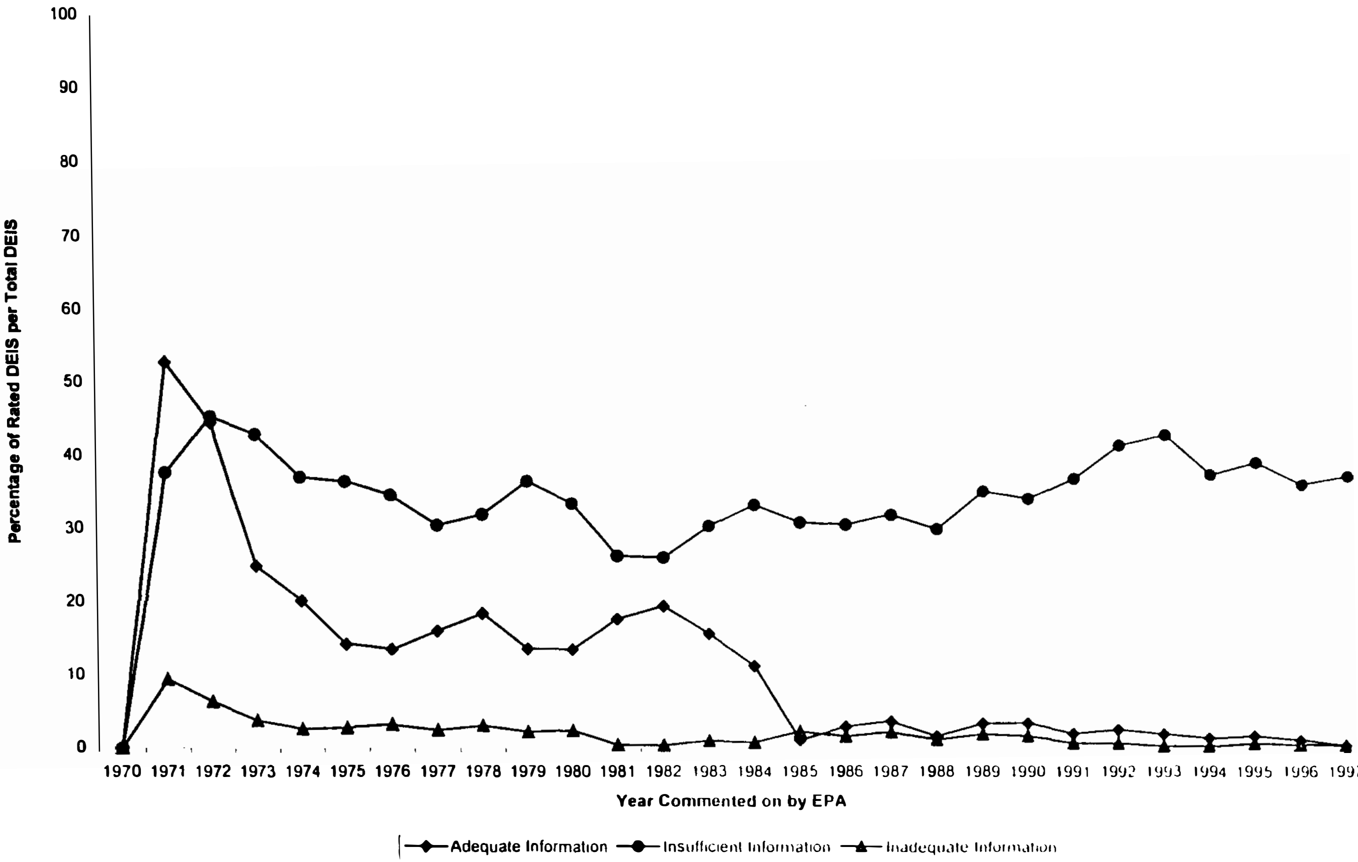
The best rating for information a DEIS can receive is adequate and the worse is inadequate. The middle category is considered insufficient. Table 4 shows the overall frequencies of ratings for information from 1970 to 1997. The greatest frequency DEISs have received is insufficient information (6,494) which accounts for 33.8 percent of the total number of documents (69 percent of the available rated DEISs). This category has clearly been used by EPA most frequently in rating information adequacy of DEISs. A distant second is the adequate rating (2,505), which is 13 percent of all total documents or 26.6 percent or the available rated DEISs. Inadequate ratings (406) were the least frequent with only accounting for 2.1 percent of the total documents (4.3 percent of the available rated DEISs). Overall, EPA is more likely to give an insufficient rating than the other categories. When this rating is further analyzed in Figure 5 some interesting trends occur.

Since 1972, basically the beginning of the NEPA, EPA has rated DEISs as less than adequate every year. While the decline appeared to somewhat stabi-

Table 4. Information ratings.

Ratings	Frequency	Percentage (includes missing data)	Valid percentage (excludes missing data)	Cumulative percentage
Adequate	2,505	13.0	26.6	26.6
Insufficient	6,494	33.8	69.0	95.7
Inadequate	406	2.1	4.3	100.0
Total rated DEIS	9,405	48.9	100.0	
Missing data	9,831	51.1		
Total DEIS	19,236	100.0		

Figure 5. The decline of adequate, stability of of indaquate and rise of insufficent ratings.



lize from 1975 to 1982, a decline begins after 1982 that continues to 1985. Since 1985, there has been a leveling of adequate documents where previous levels do not return. This similar result occurred in the LO rating, which takes place prior to the 1984 rating change in the preferred impact scale. Note, there was no change in ratings for information in 1984, so it is not expected to be a factor in these results. It appears EPA raters not only became reluctant to give out LO's during this time period, but also found documents less adequate in providing information.

Inadequate ratings are similar in visibility as EU ratings. That is, a DEIS that receives an EU or inadequate rating provides the document with political visibility, which includes EPA headquarters review and, potentially, a referral to CEQ. The bias many NEPA raters commented on in interviews was that EU's and inadequate ratings were less likely to occur because of EPA staff being reluctant to become involved in an administrative protracted process. This might explain the low frequencies that appear stable over time for inadequate documents. In sum, DEISs are not any more likely to receive an inadequate rating now than in previous years of EPA ratings.

Since 1982, there is a slow but continual increase of insufficient documents. This is the same time when adequate ratings began to decrease. Figure 5 shows that there appears to be a rise in the 1990s of insufficient DEISs. The trends of rising insufficiency and decreased adequacy of DEISs over the life span of NEPA rating is unexpected and not a positive sign for DEISs. This is a period of time when information was easier to use with the advent of affordable desktop computers. In addition, there was an expected learning and knowledge base for which DEISs upon which preparers could draw. The information ratings show that documents are not using the longevity of experience with DEIS preparation in a meaningful manner. In fact, information ratings are worse now than in the early years of DEIS ratings. Another explanation for this trend might be that raters expect more information to be used in the document because it is so much more available now than in the past. However, when NEPA raters were interviewed there was no clear evidence that this was the case. In fact, some raters felt documents may contain less useful information than in the past. In other words, preparers are not doing a good job of focusing the information in the document.

Agency Trends

The remaining questions that this research brings to attention focuses on the agency preparers of DEISs. Are some agencies better than others at preparing documents? Perhaps it is the agency newcomers who are preparing insufficient and less than top-rated DEISs. Which agencies prepare the most documents and have they improved over time? Further analysis of the data directed at answering these questions yielded some more unexpected results.

The top three agencies who most frequently prepare DEISs are Federal Highway Administration (3,996) with 20.8 percent of the total documents, then Army Corp of Engineers (3,318) with 17.2 percent and, finally, Forest Service (2,577) or 13.4 percent. These three agencies account for 51 percent of all DEISs. The remaining 49 percent of documents were prepared by 110 other agencies. The preparer of the DEIS was identified based on the agency that formally submitted the document for a rating by EPA. With the exception of Housing and Urban Development (7.2 percent) and Bureau of Land Management (5.3 percent), the remaining agencies were much less than 10 percent and the vast majority were 1 percent or less.

Figures 6 through 8 compare the trends of information ratings for these three top agencies over time. Each figure reflects the percentage of rated agency documents per number of rated documents. For instance to calculate, the Federal Highway Administration (FHWA) rating for insufficient documents, the number of documents rated insufficient was divided by the total number of insufficient documents. This same denominator was used when calculating percentage of insufficient documents for the Forest Service (FS) and the Army Corp of Engineers (ACOE). While this excludes the missing data, it was done so that the three agencies can be compared among each other.

It would be expected that these three agencies may exhibit improvement over time in adequacy of information provided in the DEISs. These agencies are among the most well-funded preparers of DEISs, and have long-standing expertise to draw upon. Theses agencies are not newcomers to the federal bureaucracy and have prepared many documents over the life span of NEPA. Figure 6 compares the adequacy ratings for these three agencies. Basically in the 1970s, the three agencies were similar in adequacy ratings. Any distinction among the agencies did not begin to happen until 1980 when FS began to lag behind the other two agencies. After 1980, we see dramatic, almost episodic changes in the three agencies. By the 1990s, ACOE had significantly lost its ability to produce adequate ratings for their DEISs. FHWA had declines and increases from year to year without any consistent pattern of performance. Likewise, during the 1990s, ACOEs had some of the highest and lowest achievement in adequacy ratings. FS, unlike the others, does appear to be producing more adequate documents in the 1990s than others. Of the three agencies, today FS is producing some of the most adequate documents. However, in Figure 7, we will see how FS also is producing the largest number of insufficient documents.

We expect the top three agencies will show signs of declining insufficiency

Figure 6. Adequate information rating.

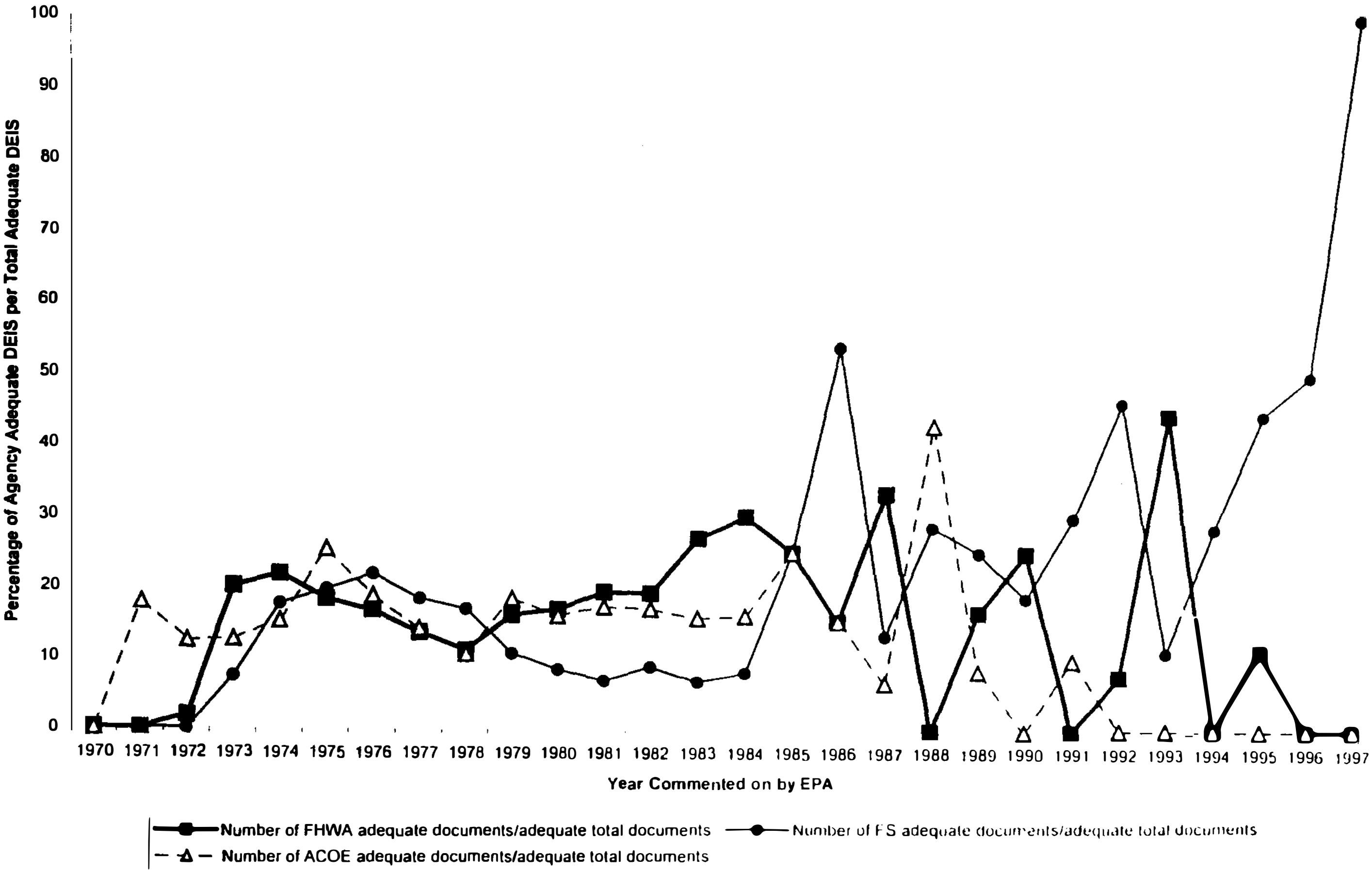


Figure 7. Insufficient information rating.

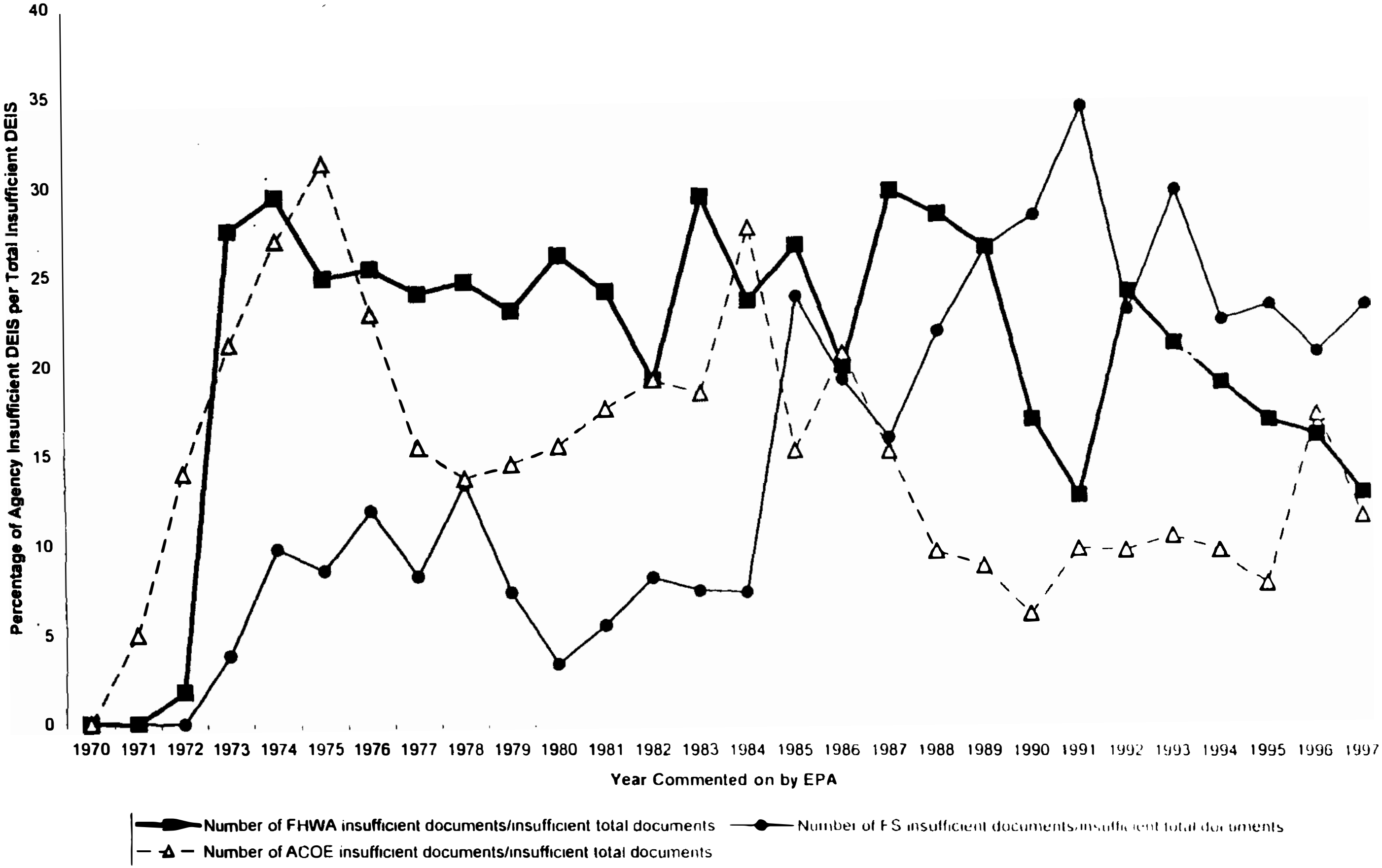
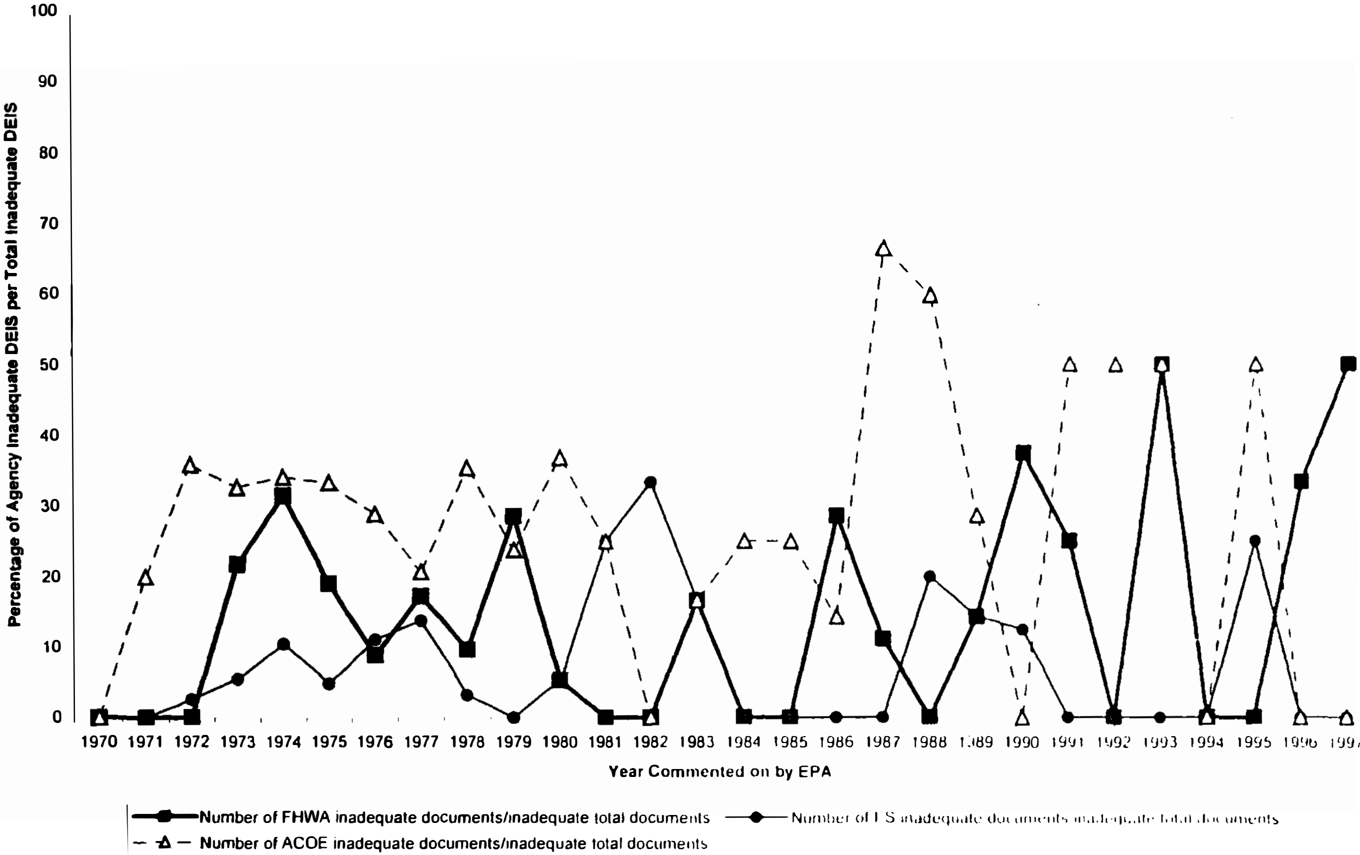


Figure 8. Inadequate information rating.



due to the benefits of expertise and frequency of preparing a DEIS. Figure 7 illustrates the performance of these agencies in providing insufficient information. Not only is FS producing some of the more adequate documents, it continues to produce the largest amount of insufficient documents. This large insufficient rating was not always the case for FS. From 1970 to 1985, FS had the lowest numbers of insufficient documents. However, in 1985 that number increased dramatically, with some periodic decreases in the late 1980s, and it continues to trend upward in the 1990s. Finding an agency producing some of the most adequate and insufficient documents is not contradictory because DEISs in the FS are produced by very autonomous field offices across the United States. What this indicates is the lack of uniform standards and understanding across FS field offices on how to prepare a DEIS. This result was confirmed in interviews with the EPA raters across the EPA Regional Offices. There were contradictory ratings given to FS and ACOE by EPA raters. One EPA rater would call out one of these three agencies as a top performer. Another rater in a different EPA Region mentioned the same agency as the worst performer. Often, several raters would cite examples of outstanding performance by a particular DEIS prepared by FS and ACOE, while also commenting how dependent the rating was based on the project manager and field office.

FHWA and ACOE tie for the second place in number of insufficient documents, although they have different histories of insufficient performance. FHWA originally had the largest number of insufficient documents during the 1970s with the exception of 1975 when ACOE surpassed it. The major difference between the agencies is that ACOE has risen and declined a couple of times before reaching today's insufficiency numbers. On the other hand, FHWA has remained the primary supplier of insufficient documents of the three agencies. It was only recently in the mid-1990s that FHWA had declining numbers of insufficient documents.

Inadequate documents showed some trends among the agencies. FS consistently prepared the least amount of inadequate documents. On the other hand, ACOE generally prepared the most inadequate documents. FHWA has experienced some large fluctuations and today has the worst record for inadequate documents.

Conclusion

Based on these results, there are a series of conclusions and recommendations that can be made. First, ratings could be used to help agencies monitor their own performance and improve DEISs. If ratings were based on more detailed and uniform content standards of acceptable analyses, preparers and the public would be better served. This would allow some standardization of preparation and understanding of the DEIS methods. It may also help courts develop consistent measures for content and quality of the DEIS rather than focusing solely on process. Reformed rating scales based on quality content could be a major force in moving DEISs out of a process focus and onto better decisions based on quality.

Overall, these results suggest that documents are not improving particularly in information quality. Agencies are not preparing quality documents in a consistent manner over time. There appears to be very little learning from previous years of DEIS preparation in information quality or environmental impact of the preferred alternative ratings. Documents are not of higher quality now than in the past. In fact, there were more top ratings of DEISs in the 1970s than today, even when standardizing for the large volume of documents in the 1970s versus later years.

In addition, the same agency is receiving both negative and positive ratings. This suggests that agency preparers in different field offices are not sharing information and resources for DEIS preparation. The agencies that have been preparing the bulk of the DEISs are not achieving top ratings on a consistent basis or even improved ratings over time. This calls for more coordination and cooperation of knowledge and NEPA resources within agencies.

Finally, clearly based on the amount of missing data, more assistance is needed for tracking and monitoring NEPA performance. It seems very wasteful to spend time preparing and rating DEISs, then to not have that information available. The public should not have to read the Federal Register to find the rating of a particular DEIS. It would be useful to the public and preparers to know which documents achieve top ratings so they could be used as models. It seems reasonable to capture all of the ratings in a national database not a regional one for practitioner and public access. The current ratings system has limitations and may not ensure a better quality document. However, the current rating scales are the only means we have to compare DEIS and agency preparation over time. At minimum, continued and better monitoring of DEIS ratings should be conducted and made available for review by DEIS preparers and the public.

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Unprecedented Decision Involving NEPA on Controversial Reservoir Project

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On June 4, 1999, the Norfolk District Corps of Engineers (COE) commander, Colonel Allan B. Carroll, made a preliminary decision to deny the Department of the Army permit needed to construct the King William Reservoir, a proposed drinking water supply for Southeastern Virginia. Colonel Carroll indicated that he based his preliminary decision "on the lack of a demonstrated need to destroy 437 acres of wetlands as well as the cumulative adverse environmental impact of the project, particularly the potential for a disproportionately high adverse effect to an American Indian minority population." This decision is compelling in many ways. Due to the highly controversial nature of the project the COE sought expert review of the project's purpose and determined that the applicant had significantly overestimated future water demands. The unsubstantiated need, coupled with the environmental consequences of the proposed project, compelled the COE to take an unpopular and fairly unprecedented action to avoid adverse impacts to the environment. In its assessment of the King William Reservoir project impacts, the COE raised the standard of environmental review and analysis to the levels originally envisioned by the authors of the National Environmental Policy Act (NEPA). Moreover, in consideration of impacts to a minority community, the COE chose to interpret its environmental justice mandate broadly and has advanced the standard of environmental analysis with respect to the rights of minority populations.

The King William Reservoir (KWR) project is a case study that will highlight the elements leading up to the controversial decision by the COE to deny a permit to build a water supply reservoir in Southeastern Virginia. Discussion of the KWR project will focus primarily on the positive aspects of the NEPA process—in particular, the high level of interagency cooperation and public participation and the quality of environmental results. The case study will also highlight a lead federal agency that genuinely incorporated environmental concerns into its decision making process. However, even "good" projects have elements that reflect the "bad and ugly" of NEPA. In the case of the KWR project, it was late developing information that resulted in permit denial after 10 years of coordination. Secondly, the multi-million dollar price tag for environmental impact assessment and project development with an uncertain outcome for the project sponsors reveals the problematic side of NEPA. Notwithstanding the bad elements, KWR project's approach in the NEPA process may be considered a bold step toward realizing the true potential of NEPA. When Congress enacted NEPA in 1970, many hoped that full disclosure of environmental impacts would lead to sound environmental action as was the case in this instance.

Project Background

The Lower Peninsula of Virginia (Lower Peninsula) has been evaluating regional alternatives to meet their long-term water supply needs since 1989. This southeastern Virginia region is in the Chesapeake Bay watershed. The area is urban/suburban in character and includes tourist attractions, such as a Colonial Williamsburg, major military installations (e.g., Langley Air Force Base) and a thriving shipbuilding industry. A regional coalition, the Regional Raw Water Supply Group (RRWSG), formed in 1989 to address future water supply issues and obtain the necessary approvals and permits required for large infrastructure development. The RRWSG is led and principally funded by Newport News Waterworks, one of the top four waterworks in Virginia and ranked in the top 100 nationally. The RRWSG projected a 39.8 million gallons per day (mgd) deficit of municipal water supply through the year 2040. In order to meet the projected need, the RRWSG proposed to create a 1,526-acre pump storage, water supply reservoir on Cohoke Mill Creek. Because the reservoir drainage area is small (8.92 square miles), the project would have involved the construction of a raw water intake and pumping station on the Mattaponi River with a withdrawal capacity of 75 mgd. The size and configuration of the KWR and the significance of environmental impacts necessitated the COE, as lead federal agency, to produce an Environmental Impact Statement (EIS) for the proposed project.

The KWR would be constructed in King William County, Virginia, a rural area with little or no commercial or industrial development. The project area is generally undisturbed except for silvicultural activity. Cohoke Mill Creek is a low-gradient stream system which lies in a valley between the Mattaponi and Pamunkey Rivers in the York River basin. The Mattaponi River is listed as a State Scenic River with tidal freshwater marshes and swamps found all along its length. The project would be located between the Mattaponi and Pamunkey Indian Reservations in an area locally referred to as the Pamunkey Neck. The Mattaponi and Pamunkey are state recognized tribes who trace their history back to the great Chief Powhatan, the father of Pocahontas, who ruled most of tidewater Virginia when Europeans arrived in 1607. The reservations, created in 1658, are believed to be the oldest in the United States.

Construction of the KWR would result in the unavoidable loss of approximately 437 acres of non-tidal, palustrine wetlands, inundation of 21 miles of stream channel, and loss of approximately 1,457 acres of forested upland habitat some of which contain mature forest. Had it been permitted, the project would represent the largest single permitted loss of wetlands in the mid-Atlantic region (Pennsylvania, Maryland, Delaware, Virginia, and West Virginia). Pumpovers from the Mattaponi River present additional concerns of salinity migration into freshwater zones and the potential for impacts to threatened shad populations in the Chesapeake Bay watershed. The significance of these impacts is amplified by the alarming rate of habitat loss, particularly of wetland resources, in the Chesapeake Bay (Tiner, 1988). Inundation of the Cohoke Creek stream valley also would affect 55 prehistoric archaeological sites (identified as prehistoric campsites, bivouacs and possible burial grounds) found within the KWR pool area. These sites and five Traditional Cultural Properties[1] were considered potentially eligible for inclusion in the National Register of Historic Places. Due to the proximity of the proposed project to Native American populations, the project also has the potential to result in disproportionately high and adverse environmental effects to a minority population as described by Executive Order 12898 on Environmental Justice.

Elements of a Controversy

The KWR project has engendered controversy from the day it was identified as the RRWSG's preferred alternative. Environmental groups active in the Chesapeake Bay region, including the Sierra Club, the Chesapeake Bay Foundation and the Southern Environmental Law Center, have presented a constant and informed opposition to the project based on the wetland impacts and impacts related to withdrawals on the Mattaponi River. In some sense, the KWR project disputes can be attributed to rural versus city polemics, reminiscent of the water rights battles of the western states. The KWR project area is approximately 50 miles from the Lower Peninsula communities it would serve. Many of the citizens of King William County resent the City of Newport News' attempts to take what they see as their land and water. Some of the fiercest

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[1] Traditional Cultural Properties have been defined under the National Historic Preservation Act as those areas that are: eligible for inclusion in the National Register because of their association with cultural practices or beliefs of a living community that, a) are rooted in that community's history and, b) are important in maintaining the continuing cultural identity of the community.

grassroots efforts to derail the KWR project come from citizens of King William County.

Native American concerns have presented another, rather unique, perspective from which to consider project impacts. Although the Mattaponi and Pamunkey Indians decry many of the same environmental impacts as the environmental community, their opposition has taken on a more fervid quality. The tribes believe that the Treaty of 1677,[2] which ceded the entire Pamunkey Neck to the Native Americans, was being violated by the RRWSG's attempts to build the KWR in the Cohoke Mill Creek valley. The state recognized treaty does not allow any encroachment within a three-mile radius of the reservation. Construction of the reservoir would have taken place within that three-mile buffer zone. The Mattaponi people also believe that their subsistence shad fishery and hatchery operation would be lost or irreparably harmed by changes in salinity and impacts to shad eggs and fry associated with the raw water intake on the Mattaponi River.

Enmeshed in this controversy is an EPA section 404(c) veto of a Department of the Army permit for a similar water supply project in the Lower Peninsula. The Ware Creek Reservoir project, originally proposed in 1984 by James City County, Virginia, involved the creation of a 1,238-acre impoundment on a tidal, freshwater tributary to the York River. The Ware Creek project would have served only the water supply needs of James City County, providing 7 mgd of treated water. EPA officially vetoed the Ware Creek project in 1989 exercising its right to prohibit the use of any site (i.e., waters of the United States) for disposal of fill material. This prohibition was based on unacceptable adverse effects on the aquatic environment including the destruction and loss of 425 acres of high quality wetlands but stemmed in part from the disturbing trend among local municipalities as they vied for independent reservoir impoundment projects. EPA viewed these projects as environmentally costly and contributing to an unacceptable trend of wetland loss and reduction in freshwater flows to the Chesapeake Bay watershed.

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2 The Treaty of 1677 describes the articles of peace established between Prince Charles II of England and the Virginia's colony Indians by among other things assigning land to English and Indian tribes. Central to the Treaty was the cessation of English confiscation of Indian lands and the establishment of a three mile buffer around Indian towns (Rountree, 1990).

The Good, the Bad and the Ugly

Developing the necessary information to fully analyze and evaluate a project as complex and controversial as the KWR cannot be done in a vacuum. All too often lead federal agencies shoulder the burden of the NEPA process alone, with limited resources, relying on an applicant's consultants to provide the data to compile an EIS. In their enthusiasm to protect the environment, other agencies may be less than cooperative in project review and development. The KWR project's NEPA process presents another scenario: agencies fully invested and engaged in the process, regardless of their position on the project, with the goal to solve problems and develop solutions. The COE also took the notable step of going "outside the box" of traditional EIS development by seeking independent review of controversial data in order to ensure adequacy and validity. The public was also well-informed during the process and as a result provided substantive comments which proved invaluable in project review.

Notwithstanding the controversy and contention surrounding the KWR process, the overall approach taken could be described as a model for interagency and applicant cooperation. KWR project scoping began with in 1989 with the primary players being the RRWSG, COE, EPA Region III, Annapolis Field Office of the Fish and Wildlife Service and the Commonwealth of Virginia's Department of Environmental Quality. The RRWSG was strongly inclined to cooperate with the process in light of the unfavorable decision on the Ware Creek project. The Ware Creek project was marked by the uncompromising position of James City County behind a fixed alternative, which polarized the process from the beginning. The RRWSG was determined not repeat this approach. Because of the veto, the RRWSG had a heightened awareness of EPA's role in the permit process. In this climate the RRWSG sought to do what James City County could not; develop a reservoir project with a regional coalition and the active cooperation of the federal and state agencies, including EPA. The natural resource agencies were wholly engaged in the process and their expertise was fully considered. Interagency teams were formed for the Habitat Evaluation Procedure (HEP) study, the wetland mitigation planning, determination of appropriate minimum instream flow values and development of the Mattaponi River monitoring protocol. The COE also regularly consulted with EPA on issues concerning environmental justice.

The final result of this cooperative effort was a NEPA document driven by the most compelling issues. An early and open scoping process concentrated on issues that were truly significant, which helped refine the analysis and generated relatively high quality information for decision making. Also, by identifying important issues up front, the EIS was able to more clearly define impacts which could be minimized or which required mitigation or compensation. The KWR project's EIS concentrated on three main environmental issues: wetland impacts, terrestrial impacts and impacts related to withdrawals from the Mattaponi River.

Because the KWR EIS was initiated in response to a wetland permit application, wetland issues were a central component and served to motivate much of the reduction in adverse impact. The FEIS provided a fairly thorough assessment of wetland resources, employing evaluation methods, such as the HEP study and a wetland diversity analysis (Shannon, Brillouin and Romme's Relative Evenness indices) to describe wetland systems and compare alternatives. The significance of wetland impact and the high quality of the resources prompted the review agencies to press for a smaller reservoir. As a result of information gathered during the Draft Environmental Impact Statement (DEIS) phase the COE was able to identify alternative reservoir configurations which significantly reduced environmental impacts while maintaining the RRWSG's project purpose. In the originally proposed configuration of the King William Reservoir (KWR-I), the reservoir would have impacted 653 acres of vegetated wetlands and open water. Moving the KWR dam 1.7 miles upstream to the currently proposed configuration (KWR-IV) resulted in the avoidance of 216 acres of wetlands and resulted in a 33 percent reduction in the overall size of the reservoir.

In order to determine the wildlife habitat value provided by the wetlands and uplands of the KWR project area, a baseline evaluation using the HEP methodology was conducted. The HEP study helped shape the compensatory mitigation plan which included not only wetland compensation but also incorporated restoration of ecosystem function including restoration/preservation of terrestrial resources at each wetland restoration site. The requirement of 2:1 replacement for wetland impacts resulted in a compensatory mitigation package with over 800 acres of wetland restoration (with priority in the York River Basin) and restoration and preservation of 1,908 acres of upland habitat. The RRWSG also agreed to restore approximately 21 miles of stream corridor by removing of dams and cattle from streams and by ameliorating agricultural practices on certain reaches in the York River Basin.

Potential for adverse impacts to the natural systems of the Mattaponi River also was determined to be a significant issue. The KWR project's FEIS assessed the potential for salinity migration as a result of the proposed withdrawals and concluded that natural salinity fluctuations in the Mattaponi River greatly exceeded any salinity changes that were predicted due to the proposed withdrawals. However, in order to validate the salinity model and its resultant conclusions, a rigorous river monitoring protocol was proposed as a component of project mitigation for the Mattaponi and Pamunkey River ecosystems. The monitoring program was intended to measure long-term trends in vegetative community composition, rare species populations and hydrologic regimes, including an evaluation of changes in sediment distribution patterns in the Mattaponi River as a result of water withdrawals and backwashing to clean the intake pipes. Mitigation measures were built into the project design in order to limit impingement and entrainment on the intake screens. The proposed raw intakes consisted of wedge-wire screens designed with a mesh opening of 1.0 mm and through-screen velocities not to exceed 25 feet per second. This design feature, recommended by the Virginia Department of Game and Inland Fisheries (VDGIF), apparently meets or exceeds the industry standards for minimizing fish mortality due to entrainment (Garman 1997). A monitoring program also was recommended by VDGIF to address and quantify impingement and entrainment impacts of the intake on larval fish and eggs.

The challenge of reviewing a broad array of complex technical data was mitigated by the COE's use of independent experts for review of certain critical issues including the salinity model and reports, potential impacts to shad fisheries, water demand projections and the Traditional Cultural Properties. These reviews, independent of the RRWSG analysis, were an important component of the KWR process because they helped level the playing field for the agencies and the public who often do not have the expertise to fully analyze certain complex technical data.

The potential for salinity migration in the Mattaponi and Pamunkey Rivers continues to be a concern despite the results of the salinity intrusion model presented in the FEIS. There was significant public criticism regarding the validity of the model developed by the Virginia Institute of Marine Science (VIMS) and the conclusions represented in its report. In order to establish the validity of the modeling performed on the Mattaponi and Pamunkey Rivers, the COE contracted with its Waterways Experiment Station (WES) in Vicksburg, Mississippi. WES reviewed the VIMS salinity model and report as well as several critiques of the model submitted by the public. WES's review was important since many of the assumptions regarding impacts to the flora and fauna of the Mattaponi River relied on the VIMS model. WES concluded that the one-dimensional salinity model developed by VIMS and the results were adequate to address the impact of freshwater withdrawals.

The COE sought to ease the Mattaponi tribe's concerns and increase their understanding of potential impacts to shad populations by requiring the RRWSG to provide a third party review of the issue. The RRWSG contracted with Dr. Gregg Garman of Virginia Commonwealth University, a noted expert in shad fisheries in Virginia, to analyze specific impacts of the proposed 75 mgd withdrawal to the shad populations in the Mattaponi River. Dr. Garman met with the tribe at the reservation to hear their concerns and to more clearly understand the issue from their point of view. His final report determined that American shad and related species in the reach of the Mattaponi River would not be significantly affected by changes in salinity and that impingement or entrainment would be mitigated by several factors, including the demersal nature of the eggs and the characteristics of the intakes screens (Garman 1997).

Substantive questions regarding the RRWSG's projected deficits for the lower Virginia Peninsula surfaced during the KWR Final Environmental Impact Statement (FEIS) comment period. In response to these comments, the COE contracted with the Institute for Water Resources (IWR), which is the COE's center of expertise for water use forecasting and water conservation. IWR issued the "Evaluation of Conflicting Views on Future Water Use in Newport News, VA Report May 1999," which detailed its analysis of water demands for the Lower Virginia Peninsula. IWR assembled a panel of four internationally renowned water resource planning experts who prepared alternative calculations of the RRWSG need, incorporating modest and well-supported changes in the questionable assumptions only. The panel's interpretation of the data indicated a significantly different water deficit than that projected by the RRWSG. The consensus of the panel was that the RRWSG had significantly overestimated future demand and that the stated need was not supported by their data. This work factored prominently in the COE's decision to deny the KWR permit. Weighing the reduced projected water need against the environmental impacts of the proposed project, the COE made a decision that the adverse impacts were not justified.

Analyzing the environmental and social effects of the proposed reservoir on the Native American communities in the project area was a difficult and sensitive issue. In the context of NEPA, the federal handle on these issues lies primarily in the 1994 Executive Order on Environmental Justice (EJ EO) and the National Historic Preservation Act's Section 106 process, which includes TCP analysis. In order to achieve the objectives of the TCP guidelines and EJ EO, communication with the tribes had to be sensitive to the "comfort level" of the tribes. The issue of cultural practices and beliefs and cultural identity was a difficult subject for the tribe to discuss to outsiders. Complicating the situation was the fact that the RRWSG, who would normally fund all the technical work related to the EIS, was not trusted by the tribes. Given the circumstance, EPA provided the COE with funds to be used for the expertise of an ethnographer/anthropologist to conduct the TCP study and analysis of environmental justice concerns. The study identified five TCPs and discussed potential effects. In consultation with the tribes, discussion of mitigation measures to offset adverse impacts also was conducted. As a result of the TCP study the RRWSG agreed to enter into negotiations with the Mattaponi, Pamunkey and Upper Mattaponi Tribes in order to determine what, if any, compensation could be offered to offset adverse impacts to the tribes. In deference to the tribe's wishes, the terms of any agreement were not to be revealed to the general public. As a result of the COE's June 1999 preliminary denial, negotiations were never finalized. What remains important, however, is that by broadly interpreting its obligations under NEPA, the COE was able to fully consider cultural and social issues, identify impacts and discuss mitigation with direct input from the affected community.

Public involvement is an important component of NEPA and public disclosure of information is an important objective of NEPA. The level of public involvement and scrutiny in the KWR project has been extremely high. Environmental groups, as well as the Mattaponi Indian tribe and their legal representation, the Institute for Public Representation, mounted a well-organized and often well-informed campaign against the project. The environmental community and the tribes took advantage of their own outside experts and in some cases, provided well-written and compelling arguments. In the case of the water demand projections it was the comments raised primarily by the environmental groups that led the COE to revisit the issue. Once the environmental justices issues were identified, the COE provided ample opportunities for tribal input in the NEPA process, including identifying potential effects and mitigation measures. In order to provide meaningful participation by the tribes in the process, the COE improved the accessibility of meetings with the tribes by meeting at the reservation sometimes in the evening or on weekends. This empowered the tribes to become part of the process, offering their own unique view to a complex project.

The KWR project's NEPA process doesn't present an entirely rosy picture. Consultation and development of the KWR project has taken 10 years and by current estimates has cost the RRWSG approximately $12 million. The reasons for this are varied and most probably debatable. Although in some respects the process demonstrates a model of interagency cooperation, this coordination did not develop overnight. Significant time and money were expended before a level of trust was developed among the all the agencies and then between the agencies and the RRWSG. Blind alleys and false starts characterized some of the initial work on the project, which can be expected in a project of this size. For instance, due to the complexity of the project, a tiering of the EIS was initiated in the early phases of project development. The tiered approach, however, became unwieldy and was eventually abandoned. Moreover, although the RRWSG began meeting in 1989, it was not until 1994 the Draft EIS (DEIS) was issued. Five years were spent on alternatives, analysis and project development, including scoping of environmental issues. Despite these up-front efforts, however, the DEIS was deemed to be inadequate because it did not contain sufficient information to fully assess environmental impacts and required a supplement. It also became apparent in the DEIS stage that additional impacts could be avoided by changing the dam location and reconfiguring the reservoir. The RRWSG resisted these changes, and it took three years of negotiation to reach the compromise of the KWR IV.

Until comments were raised by the public, the resource agencies, including the COE and EPA, believed the information in the DEIS and FEIS was adequate for the purposes of NEPA. The federal natural resources agencies are generally not equipped to provide such a thorough technical analysis of water demands. The critical public comments and the IWR analysis, which found discrepancies with the RRWSG's demand projections, were both highly technical reviews of the demographic and water demand methodologies. The unfortunate result was a questioning of the project's purpose and need nearly seven years after the RRWSG presented their water deficit projections.

Although the document provided valuable information for decision making, it also was very lengthy and complex, a daunting task to review, particularly for the public. Because the document was compiled by the RRWSG some vague conclusions and unsupported data remained in the COE's FEIS. Important elements, such as the TCP study and the wetland mitigation plan, were not completed by the time of issuance of the FEIS and subsequently were not included in the document. More importantly, the IWR Report, which casts significant doubt on the water demand projections, is not in the FEIS and lies outside the official NEPA framework. Although these documents have all contributed to the COE' decision, the public has not had the opportunity to review and comment on them. The COE may chose to redress this issue by circulating their Record of Decision for public review and comment.

After 10 years of information gathering and project development, the fate of the KWR project remains uncertain. The COE has provided the RRWSG another opportunity to rebut the IWR's May 1999 report, but the time frame of that response is uncertain. If the COE upholds its preliminary decision to deny the project it will be further complicated by the State's disagreement with the COE's decision. Because Virginia's Governor has opposed the District Engineer's tentative denial in writing, the permit decision will be referred to the COE's Mid-Atlantic Division pursuant to 33 CFR 325.4(b)(2), unless the District Engineer reverses the decision. Whatever decision is reached—denial or issuance—the project may continue to have a long life of uncertainty in the courts. A similar water supply project for Virginia Beach, Virginia, languished in the courts for many years. The tap was just recently turned on for the Lake Gaston project after its first round with the NEPA process in 1984.

It is sometimes inevitable that complicated debates become defined by their extreme positions, especially more so when they draw the attention of the mass media. Although public involvement in the KWR project has been largely a positive experience, the portrayal of certain impacts was propagandized by both project opponents and proponents. Certain issues gained a life of their own, out of proportion to their real impact. For instance, concerns regarding catastrophic impacts to the Mattaponi River ecosystem and shad fishery are obviously overstated. In review of the data, most experts agree that with the conditions placed on the withdrawals and the use of the proposed intake screens, impacts to the river and shad fishery should not be significant. It becomes difficult to continue a dialogue based on trust when issues become distorted and no middle ground can be sought. The project opponents were not alone in the misrepresentation of information. The RRWSG for its part continues to assert that the construction of the KWR project will have little, if any, adverse impacts. Any impacts that are realized, such as wetland loss, will be easily mitigated and most likely offset by the enormous gain in open water created by the reservoir.

Lessons Learned

NEPA is a process-oriented law, and all too often the process is followed but the true "spirit" of NEPA is ignored. Getting through the process is frequently the unspoken goal, while real understanding of environmental consequences to aid better decision making is not sought. Despite the problems encountered during the KWR process, it does present many positive lessons for successful environmental protection in public deliberations. Regardless of their position on the proposed project, agencies became engaged in the process, avoided polarization and sought solutions rather than creating impediments. The applicant also engaged in the process and, although hesitatingly at first, worked to scale back the project thereby minimizing environmental impacts. The KWR project may have raised the bar for environmental review and analysis on large, environmentally costly projects. By engaging the entire suite of interested parties, the lead federal agency was compelled to investigate a full range of potential solutions. The process demonstrated that real environmental gains can be realized if the process is genuine and thorough. Efforts to change or "fix" NEPA need to take an honest look at the good as well as the ineffectual or time consuming, to effect changes in the process. NEPA policy is essentially sound. All too often it is the actors who set the stage as to whether the process leads to the good, the bad or the ugly.

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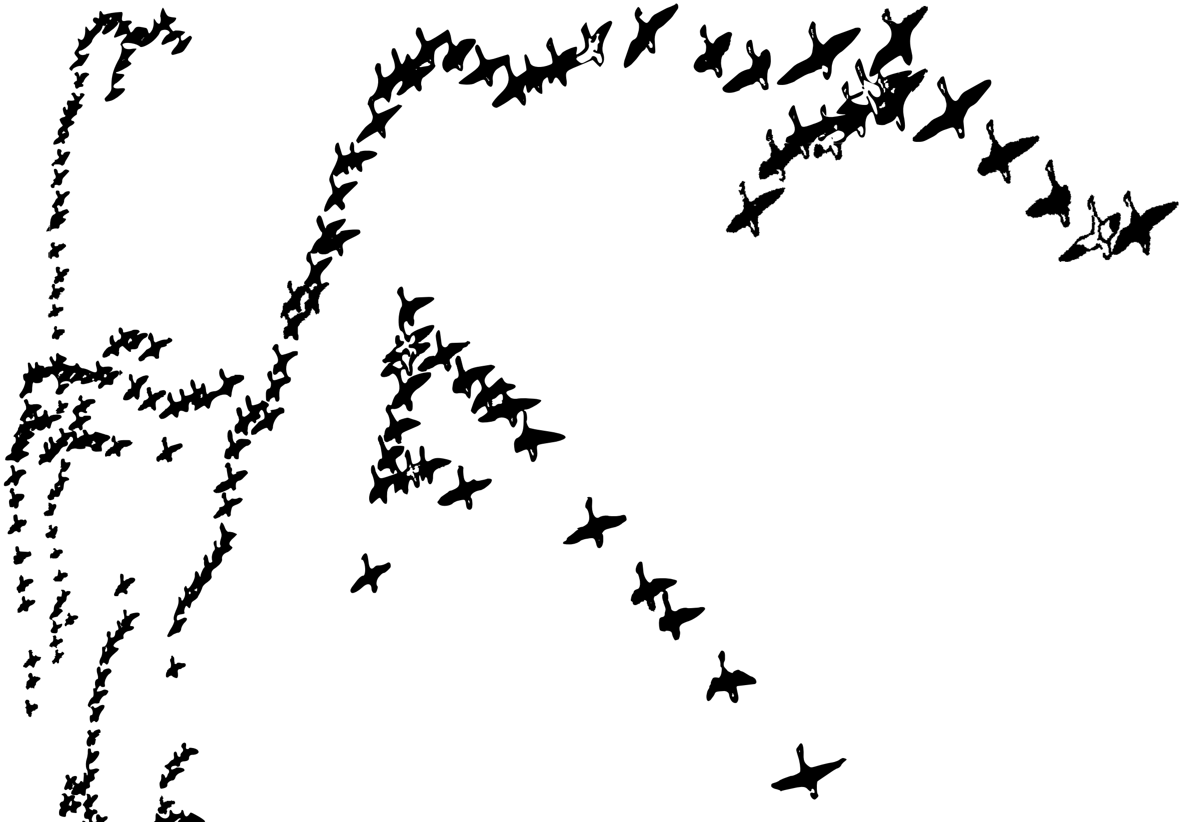

Session Six.
Young Wildlife Professionals: Do They Fulfill The Needs of Management in Today's Resource Agency?

Chair
GORDON C. ROBERTSON
West Virginia Department of Natural Resources
Charleston

Co-chair
THOMAS D. NUDDS
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Great Books, Great Thinkers, Great Fish and Wildlife Agencies

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I have worked in the field of wildlife biology, at a government institution, for nearly 20 years. Even so, after learning that my abstract had been accepted, the reality of "who am I to offer comments on this session theme?" set in. Yet, upon further reflection, I concluded that a career at midpoint can and does offer an opportunity to share some thoughts and ideas that I trust will prove to be provocative, insightful and hopefully beneficial.

These comments are the result of a lot of reading, personal experience and observation, and some attempt at systematic, coherent, world-view based thinking. I do not, however, pretend to be an authority on any of the subject areas that I may intrude into today—I am certainly not, by strict definition, a philosopher, educator or historian.

This presentation will revolve around four topic headings: government and government service; fish and wildlife professionals at work; the intellectual capital needed by fish and wildlife agencies; and, a path. One business writer has observed, pay bonuses for leaders should be deferred until one learns how well their decisions benefit an organization 5 to 10 years later; as opposed to present or simply short-term performance. My comments are made today with such a humble eye to that future because I truly care about our profession, institutions and conservation mission.

Government and Government Service

The public sector, or government service, is a challenging and complex environment in which to work. Resources are limited, demands and expectations are very high, and customers are diverse. Access to information is almost instantaneous and litigation is utilized as a tool of delay, fund-raising and outright program derailment at the drop of a hat. All decisions and data are in the open and the decision-making environment is entangled by both executive and legislative constraints or demands. Behn (1994) wrote: "Managing any organization is a challenge. But there are major differences between a business firm and a government agency. These differences mean that public managers often face an even more challenging job than their private-sector colleagues:

- Public managers have many more rules and regulations that constrain their flexibility to deploy people, money and other resources.
- Public managers work in a goldfish bowl, with many people checking to make sure that they do not make some trivial mistake.
- Public managers have to be responsive to many more stakeholders — not just those who receive the services their agencies provide.
- Public managers work for a large board of directors, whose members possess conflicting views about what any agency should do. The board has not been chosen by the CEO, and many directors are openly plotting a hostile takeover.
- Public managers do not have the luxury of being able to quietly develop a new product or system over several years. They must produce instantaneous results."

Sound familiar? But such is the warp and woof of the democratic milieu. I have concluded that it is important to keep that reality in perspective and to look at the complexity as opportunities; challenges for growth, development and profound learning — making public service not only valuable conceptually but also experientially and pragmatically. Public service offers chaos *and* unlimited learning opportunities. Instead of frustration it can and should offer rewards and fulfillment — even though in the midst of controversy it may be downright difficult to observe or appreciate at any given moment. We need to remember what Behn goes on to state in the article cited above: "Business management looks substantially easier. Nevertheless public management has one important advantage. The tasks of public agencies — and thus of public managers — are extremely important."

Fish and Wildlife Professionals at Work

Are the challenges any different for state fish and wildlife agencies? I think not. In fact, they may be more difficult because so many people enjoy wildlife in our society and express opinions about it. Many studies indicate that huge numbers of people enjoy wildlife for a variety of uses including hunting, angling, observation, feeding, and photography. See for example the data from many state and national surveys in *Wildlife and the American Mind* (Duda et al. 1998). These constituents have diverse values about wildlife and expectations for their management, and conflicts, therefore, should come as no surprise. Jamieson (1995) wrote: "A generation ago wildlife managers were unquestioned authorities; questions of individual animal welfare were largely ignored. Conflict is the price of taking animals seriously."

Management assumptions about lethal control, habitat values and the role of public involvement are questioned. As noted about government service in general, information transfer is unlimited, litigation or administrative challenges through rule-making are commonplace, and access to biologists and administrators, is relatively easy, at least in a small state like Vermont. Last year, after approving an expansion of the area open to moose hunting, I was chagrined to learn my email address was on a "save the moose web site," and because of which I was overwhelmed with electronic form letters. When one of the statewide prohunting organizations wanted to promote my email address to effect equanimity in the numbers game, I was not certain I wanted to allow to a doubling of my email.

Could I have predicted this? Sure, I know enough about technology and the historic emotional response to moose hunting so I should not have been surprised. Could I have prevented it? Maybe, with additional reliance on public involvement tools (and we already had done a fair amount of that). However, the terms of engagement are also important to understand. We need to be ready to appeal not only to science, but to the humanities *and* science to carry the day in public policy debates. Or as Jamieson (1995) wrote: "One thing we can be sure of is this: these conflicts cannot be resolved by technocratic appeals to economics, management or science. We are all going to have to become philosophers."

Fish and Wildlife Agencies Need Intellectual Capital

One of the biggest challenges facing government fish and wildlife agencies, in my opinion, is the sophistication of the American mind. This is especially true of those often opposed to our public policy initiatives that deal with animal welfare, population versus individual management paradigms, and man's relationship to wildlife. Past answers such as "this harvest is needed to assure population health" or these exotic animals must be lethally controlled to ensure ecosystem integrity" may no longer suffice. Instead, we best be prepared to address completely different moral presuppositions in a thoughtful way. It is instructive to note that even with our more traditional management allies, there can be a substantiative, pre-suppositional gap over the broader conservation goals of agencies when discussing rattlesnake habitat protection or the ecological value of predators, for example.

Again, I have decided that such challenges can be constructive. They are certainly part of the fabric of decision making for agency heads, lands managers and harvest biologists. To complain, circumvent or out-maneuver may work in the short run. However, for long-term agency effectiveness I believe direct engagement with the best possible thinkers agencies can muster is the far better field of choice.

I believe our universities and in-house professional development programs train competent managers and scientists—people able to conduct hypothesis tests, design population models, develop public attitude surveys, and demarcate habitat features on sophisticated computer programs. I also believe our profession has rightly encouraged the development of better communicators and has embraced the need for improved focus upon public outreach and collaborative public input. However, it is my distinct impression that the biological or social sciences (i.e., human dimensions) will not, in fact, be sufficient to address the continuing complexity of decision making for the next century. Instead, we need excellence in thinking, especially critical thinking skills at all levels of our fish and wildlife agencies. We need staff who understand and can communicate empirical data from population or human dimension surveys, on which we typically base management decisions. However, we need much more—integrated and critical thinking skills to engage critics and skeptics with rigor. That means, at the very least, well-read employees, young and old, in the spirit of Leopold's chalkboard admonition, "Reading maketh a full person" (Jahn 1998).

We need not only staff versed in conservation biology, education and sociology, or natural history alone because even *A Sand County Almanac* will fail us; but also readers of ethics, philosophy, religion, and history. Unto that end, shouldn't we expect employees to be familiar with De Tocqueville's *Democracy in America*? How can we ignore the foremost commentary on the democratic establishments within which we work? What about reading biblical commentaries on creation for a better understanding of Hebrew terms for stewardship to better prepare us for the pervasive stewardship/dominion debate? What about reading Plato or Aristotle, whose works have had a profound influence on the development of western thought? It is my impression that many animal rights, wilderness and environmental advocates have read works such as these and gained the necessary footing to throw us off balance from time to time.

And, what about fiction? Would it be too much to think our employees would have read Dostoevsky or Tolstoy—Russians who look deep into the human heart and offer powerful insights about the human condition? What about George Eliot and her ability to explore the depths of human relationships? Or what about Charles Dickens and his fictionalized accounts of industrial England and its impacts on society. These works and many others teach a great deal about the human condition and the development of thought towards culture, animals, man's relationship to man and/or man's relationship to nature.

In my opinion, a broader reading list prepares us to intelligently craft a world view that integrates hard sciences and humanities. People need data, but they also need it from articulate, learned naturalists and students of humanity. Orr (1994) wrote: "A second danger of formal schooling is that it will imprint a disciplinary template onto impressionable minds and with it the belief that the world really is as disconnected as the divisions, disciplines and subdivisions of the typical curriculum. Students come to believe that there is such a thing as politics separate from ecology or that economics has nothing to do with physics. Yet, the world is not this way, and except for the temporary convenience of analysis, it cannot be broken into disciplines and specialization without doing serious harm to the world and to the minds and lives of people who believe that it can be. We often forget to tell students that the convenience was temporary, and more seriously, we fail to show how things can be made whole again. One result is that students graduate without knowing how to think in whole systems, how to find connections, how to ask big questions, and how to separate the trivial from the important. Now more than ever, however, we need people who think broadly and who understand systems, connections, patterns, and root causes."

Could this be what made Leopold so special in terms of how he could, and did, engage his readers? Orr wrote that Leopold "began his career as something of a technician, but he outgrew it. *A Sand County Almanac*, written shortly before his death, was a nearly perfect blend of science, natural history, and philosophy." The question facing us today, in order to reap benefits 5 to 10 years in the future, is "how can we—public agency leaders, teachers and mentors—replicate that?"

A Path

There are no easy answers—we have created a profession that thrives on specialization and science. And I am not criticizing that per se—I take no exception to training or employing species specialists or community ecologists. Our academic institutions and systems have served us well, but I believe it would be desirable to revisit whether or not we are on the appropriate course for the future. But let me offer some food for thought; first at the academic level and then in the so-called workplace.

Training Students

First to the easy wins. Faculty should continue to look for opportunities to offer integrated, critical thinking problems to work on within existing course offerings, which I already see the evidence of in my exposure to academia. Orr (1994) offers much food for thought in this regard. Additionally there must be missed opportunities at monthly meetings of professional student societies. I propose it would be as desirable to invite faculty from the religious studies program or the philosophy department as it would be an agency biologist or nationally known conservation biologist.

As an excursus—it is also important to wed the heart and the mind, intellectual rigor with real world experiences. I am not sure of the demographic background of students going into fisheries or wildlife programs these days, but it seems that some of the students I meet have not spent much time in the woods. Beyond that, there is a clear need for more student exposure to some real world activities, such as trapping or hunting with hounds, with the real people who participate in these avocations

The bigger challenge, of course, may be in terms of curriculum design. I think it would be worth revisiting the interactions of traditional wildlife and environmental studies programs at the undergraduate level. Perhaps some of the science courses of traditional wildlife programs will need to yield to more humanities courses or special, critical thinking projects. But would that be all bad? Especially since virtually all new hires as biologists come to state agencies with M.S. or Ph.D. degrees marked by additional academic opportunities for hard science.

Agency Contributions

It is important to remember that government agencies can and should do more to foster critical thinking and lifelong learning, and it would be wrong to simply turn to our universities to solve the problems. Even within our government institutions there are tremendous opportunities for new learning. Consider this short list, for example:

- *Book groups*: Noontime or even work day book discussion groups are easy to initiate. My senior managers and I are now meeting a few times a year, over pizza, to discuss management and organization books. I am open to even reading some fiction.
- *Professional meetings*: First we need to do a better job of getting staff to professional meetings and when hosting them to develop provocative sessions. Plus, I think we should send staff to new and radically different meetings. For instance, I'd like to go to a meeting of the Association of Quality and Participation in the future—to experience first hand what the quality movement in the private sector has to offer public managers.
- *New journals*: Our institutional libraries should have the basics—*Ecology*, *Journal of Mammalogy*, *Conservation Biology*, and The Wildlife Society and American Fisheries Society publications. But I believe, for a modest investment, the shelves should also contain *Environmental Ethics*, *The Journal for Quality and Participation*, and other educational, philosophical or organizational periodicals. We have started to subscribe to such periodicals, making them at least accessible to those who might want to explore some different thinking in related fields.

These are relatively easy options—merely requiring extra dollars or shelf space. I think, there are at least two other major challenges for supervisors, leaders and administrators. First, we need to communicate a passion for the learning organization. Senge (1999) wrote "Change can only be initiated by small groups of thoughtful leaders who truly desire to build an organization where people are committed to a larger purpose and to thinking for themselves." One way we lead learning to occur is by asking questions of staff about their presuppositions that led to recommendations or policy initiatives. In other words we need to be bold and thoughtful enough ourselves to model an inquiring mind. Over time such behavior will trickle down to enforcement or deer harvest decision making.

Second, in that learning environment agency leaders must at least acknowledge the profound reality that there is a lot we don't understand about natural resources, management impacts or ecological processes. This will help to reenforce the premise that a learning or thinking organization is not a luxury but a necessity.

Conclusion

The title of this paper implies a simple linear solution for fish and wildlife agency effectiveness in the future. Books, even great ones, are only a portion of the solution. I hope it is clear that the burden really falls on the investment of intellectual leadership by deans and directors, professors and program managers. For our universities, I agree with Jacobson and McDuff (1998) that we must avoid the matriculation of idiot savants. In our agencies, we must cultivate learning systems that offer opportunities for broad and integrated growth in knowledge. Only this combined commitment will adequately prepare fish and wildlife agencies for the ever-changing complexities of fish and wildlife resource management in the public sphere.

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Does Today's Wildlife Management Agency Know What to Expect From Young Wildlife Professionals?

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Ten years ago a paper presented at this Conference titled "University Education in Wildlife Biology: What's Given and What's Needed" (Teer et al. 1990) gave the perspective of four respected colleagues who represented state and federal agencies, a professional society and a wildlife research foundation. Each of them was an acknowledged leader in his field and had considerable academic background and experience in the wildlife profession. Based on their vast experience in university education and in employing graduates, as well as serving on review teams of university research and educational programs, they identified a number of concerns and changes needed, and they reached some emphatic conclusions. In addition, they referenced a number of excellent studies and opinion papers by respected educators and researchers, all of which provided stimulating food for thought. One of the conclusions in that paper was stated as, "We submit that wildlife education in most universities and colleges does not adequately fill the needs of young professionals or the management agencies that hire them." (Teer et al. 1990). Inherent in this and other important conclusions were the significant changes that occurred during the relatively brief history of the wildlife profession in the U.S., whether one traces the profession's beginning back to the early 1900s, to the publication of Leopold's (1933) textbook "Game Management," or to the establishment of The Wildlife Society (TWS) in 1937. Teer et al. pointed out, and rightly so, that significant changes within the profession occurred during 1980s; and I submit that many more significant changes have occurred in the decade since their paper was presented.

I suspect that most of us who have been involved in the profession for the past 30 years or more can agree that the profession has become increasingly complex and will likely continue to do so in the future. Is this a bad omen that plagues only those of us in the wildlife profession? While I cannot speak for other disciplines, I suspect that a number of them also are finding their profession growing increasingly complex. This is particularly true for those who must be accountable to a society becoming progressively diverse, litigious and more demanding of public officials and servants, as well as predominantly urban and generally better educated than in the past. Can we solve all these concerns and return to a situation where the wildlife professionals' work will become less complex? I doubt it. Rather than blaming the increasing regulatory edicts which began in the late 1960s, the rapidly advancing technologies or other sources of this complexity, we need to be more proactive—recognizing that change is inevitable and exploring some alternatives and partnerships that will enable us to continue to move forward while building on past successes.

For the past 21 years, I have worked predominantly with land grant institutions' wildlife and fisheries programs nationwide; and for the past six years, I have worked directly with department heads and faculty on research, teaching and extension programs, as well as serving as team leader for comprehensive reviews of their programs and as the reviewer for a significant number of Hatch, McIntire-Stennis and National Research Initiative project proposals. This experience with land grant programs has provided me some insights and perspectives, and it enables me to reach several conclusions about our wildlife educational programs. These conclusions also are tempered by my service on advisory committees for a number of these institutions; by listening to the comments of faculty, students, stakeholders, and cooperators invited into the comprehensive review process; and by summarizing the review findings into final reports.

Since many, if not most, of us in the "geezer" age-class are professionals who gained much of our formal education within the land grant university system, we owe those who trained, mentored and guided us a great debt of gratitude. They have contributed significantly to our profession. However, as appreciative as we might be, few of us would claim that we obtained everything we needed to become a competent professional from our academic education. I think we recognize that our learning curve escalated sharply as we entered the profession or, for some of us, reentered it after graduate school. Hopefully, we were quick studies and recognized early on the need to learn from our experiences and from already experienced mentors. In retrospect, I contend that it is more difficult today than it was in the past for faculty members to be able to devote as much time and field guidance individually to students as most of us received in our education 20 to 40 years ago. There are a number of reasons for this, including lack of appropriate operational funding, too few professors and too many students, and changes in departmental priorities such as less interest by other departments in teaching essential mammalogy and ornithology courses or other essential courses traditionally offered in the past. But here again, let's get real. It is, in my opinion, virtually impossible for a department of wildlife and fishery sciences to turn out students with everything they need to be—technically and scientifically capable; well rounded in the comprehensive knowledge of how all the pieces of the puzzle fit together on the land; and with all the social, communication, and "hands-on" management skills employers would like them to have—unless they have already obtained some on-the-ground experience and working skills and have returned for additional graduate work.

Some significant academic problems need to be addressed. The most obvious in some schools is that there is little or no focus on interdisciplinary research or teaching of senior and graduate-level courses across natural resource disciplines. In some cases, this is because the required curriculum in each department is jam-packed already and faculty members are so engrossed in their own research, funded primarily through extramural sources, that there is too little time to collaborate with other faculty to develop and/or expend the planning time to teach such courses. In fact, even in some schools of natural resources where departments are housed in the same buildings, there often seems to be an imaginary line that will not be breached to conduct interdisciplinary research projects, much less to share the teaching load for a multidisciplinary course, and there is a lack of appropriate incentives to promote interdisciplinary research and teaching. These institutional and disciplinary barriers must be overcome if universities expect to prepare students capable of addressing complex issues of the future.

With all this said, let me add that respected institutions of higher learning continue to turn out quality students and future leaders in our profession because they have dedicated faculty members who genuinely care and are committed to helping students. One factor involved here is that many wildlife departments have imposed a real or imaginary cap for the number of both graduate and undergraduate students simply because the demand is great enough to enable them to require high grade point averages. Thus, only the brightest students can get in, and these are the ones most likely to have high academic performance. I certainly don't blame them for doing this. Yet this practice may prevent some students who have the potential to make outstanding wildlife professionals, but lack a high grade point average for whatever reason, from being accepted in a program he or she really desires.

Culture and Value Influences—Past and Present

Obviously, not all of us aging wildlifers came from rural backgrounds and cultures, but many did. In my case, on our farm it was both commonplace and accepted that livestock and their products were grown and managed for use as family food or for the market. Hunting, fishing and wildlife damage management were both practical and recreational activities that supplemented our food sources. Trapping of furbearers supplemented my personal income. Animal welfare, as difficult as it may be for some to understand, was a prerequisite and not to be abrogated. Children and adults were held to the same standards for humane treatment of animals, and anyone breaching this unwritten code was considered a social outcast by the community. Killing of hogs or cattle for food was a necessary family- and community-shared activity during the winter months, and fresh meat was shared communally and with families in need. If a family or neighbor had a problem with predation on their poultry or livestock, someone in the community skilled in damage prevention or control techniques helped out.

I share this because it reflects influences that helped shape the philosophy and management perspective of many early members of the wildlife profession. Whether this past history is understood and/or embraced by many young people entering the wildlife profession today is not important. Nor is this past history presented as a defense of this value system or cultural background. It is presented because it is a realistic reflection of the culture of many early wildlife managers.

Obviously, rural cultures and values have changed significantly during the past 40 years. Our progressively more urbanized society continues to change its outlook on wildlife and the environment, and these changes are reflected in the motivation of students enrolling in wildlife curricula and those graduating and moving into the profession today. The great majority of students entering the profession in recent years would be hard-pressed to comprehend, and might be appalled by, the cultures and values I briefly described above. They have been influenced by the culture and value system they were exposed to in the environment in which they were raised. Respected natural resource educators and social scientists have examined these changes and influences for a number of years. Here are some of their findings.

Brown et al. (1992), in a study of members of The Wildlife Society, found that the respondents (84.1 percent of whom were males) overwhelmingly approved of hunting and trapping and felt that using wildlife gives society a vested interest in long-term conservation. In contrast, Angus (1995), examining gender differences among wildlife professionals, found that the two most important influences for men entering the wildlife profession were hunting and fishing, whereas for women they were hiking and camping. Another study of gender attitudes (Sanborn and Schmidt 1995) revealed that women wildlife professionals were less supportive of traditional wildlife management concerns such as game and pest management than were men in the profession. In a more recent study (Muth et al. 1998) of conservation professionals from three professional societies and a professional association, with respondents comprised of 58.9 percent males and 41.1 percent females, the following data were revealed: 80.6 percent agreed that, "Humans can harvest surplus production of wildlife and fish populations without harming their long-term population viability." However, only 52.5 percent agreed with the statement that, "Wildlife and fish are resources to be harvested in a sustainable way and used for human benefit." In regard to methods of harvest, 57.0 percent of the respondents agreed to the statement, "Use of dogs to hunt black bears should be outlawed." In regard to trapping, although the majority felt that trapping was appropriate for sport or subsistence, 46.1 percent favored outlawing the use of leg-hold traps. The authors' conclusions suggest that these findings reflect the complexities of the issues within the professional conservation community, some shared attitudes and values with regard to many of the issues, yet significant disagreement on other issues.

These and other self-examinations provide important inferences about the profession, and may indicate future considerations for management agencies and professional societies. However, the bottom line is that the need for change is evident and must be addressed.

In the recent document "Survival in the 21st Century," based on the Proactive Strategies for Fish and Wildlife Management Project findings, the following statement was made, "The uncommitted 80 percent of the public holds essentially positive values toward wildlife, but does not consider it a high priority in their day-to-day lives. Their concern for wildlife is analogous to the public concern for efficient highways or clean air. The uncommitted public encounters wildlife: they do not seek it out" (International Association of Fish and Wildlife Agencies 1998). Clearly, other segments of the committed public have strong feelings about wildlife, including those who value wildlife for consumptive use, enjoyment and conservation, our "traditional supporters," and those whose principal interest is the preservation and protection of wildlife, excluding management. As noted by Dizard (1994), this latter group perceives wild nature as benign and existing in a harmonious state of balance if left free of human interference. These statements identify some serious challenges for the wildlife profession and for other natural resource professions as well. Most of us who have been around awhile have been witness to significant social, cultural and demographic changes. Clearly, these changes have altered the way we do our work and the clientele we serve. But have we changed rapidly enough to address the values this diverse public is willing to accept?

Muth et al. (1997) noted that most Americans no longer have direct experience with the natural world, but experience it through an urban perspective associated with television nature presentations; movies such as "Bambi," "Free Willy" and "Babe"; urban zoos and Sea Worlds; and their own backyard bird feeders. In a more recent analysis, Muth et al. (1998) stated that, "Once principally comprised of sportsmen, wildlife and fisheries stakeholder groups have broadened considerably, ranging from the expanded participation by non-traditional publics, such as women, ethnic minorities and urban residents, to an increasing array of non-consumptive users, such as bird watchers and photographers, to animal protection activists, many of whom oppose management and human use of wildlife and fish resources."

Wildlife Management Agencies' Expectations

Teer et al. (1990) concluded that most wildlife management agencies "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 negotiating whatever the 'system' is that defines the management arena." These authors make a strong case that a baccalaureate degree should not be the terminal degree for a wildlife biologist, and that specialization should begin and need not end at the Masters level. In the Proactive Strategies for Fish and Wildlife Management Project (PAS) Report (International Association of Fish and Wildlife Association 1998), it was suggested that this project had "helped bring about a paradigm shift in the fish and wildlife management 'culture' towards recognizing the potential impacts of cultural and demographic changes in North American Society, how our agencies may be out of step with these changes, and the important role human dimensions research, outreach and 'new' techniques like marketing bring to wildlife conservation."

The important question here is: "Has this changed the agencies' expectations of what young professionals should be equipped with when they leave their university education?" I cannot conclusively answer this question; however, after review of a number of references in preparation of this paper and my own experience in listening to concerns expressed by experienced management agency professionals, my best guess is "Yes." Management agencies, like universities, would like to be able to employ biologists or faculty members who have the desired education, skills, experience, and capabilities to hit-the-ground running and perform all their responsibilities without hesitation or failure. Are these expectations realistic in today's complex society—and given the increased stakeholder expectations of knowledge about game, non-game, endangered species, new technologies, conflict resolution, public policy, human/wildlife interactions, a diversity of urban wildlife and habitat interests, and other management and ecological information being required of professionals? Unequivocally, "No." This does not mean we should ignore the need to obtain the needed skills, knowledge and scientific capabilities. I certainly agree that wildlife curricula have evolved significantly from what they were in the past and will continue to evolve with changes in core curricula, capstone courses, and other developing academic strategies. I agree that the development of a base in scientific management knowledge should come from the universities; however, I contend that the skills and capabilities to use these basics mature through employment in the profession. In my opinion, the development of capable professional wildlife managers is a mutual responsibility of both the educational institutions and the management agencies. The universities alone cannot produce the complete wildlife biologist. Clearly, agencies should be interacting with the universities about their needs, and faculty members and department heads need to periodically evaluate their curricula and collaborate with management agencies to address the concerns of major employing agencies. It is imperative that management agencies invest in continuing educational needs, aside from just paying the salaries of these employees while they gain the years of field experience needed to become competent professionals.

This is not a blanket indictment of either university wildlife departments or wildlife management agencies, as many of them are working on and implementing changes. Others are not. Most of us left our educational institutions brimming with knowledge and enthusiasm, feeling we were prepared for anything. But after that initial fire simmers, each individual must recognize the need for and pursue continuing professional development. Each individual agency must take the responsibility for making this possible over time. Let's examine some management agency opportunities that could decrease the gap time between a green new employee and a better-equipped and capable professional. The following would require an investment by the agency and collaboration with universities, but likely would pay long-term dividends:

Considerations for Management Agencies

1. Work with universities to establish co-op work/study programs if they are not already in place for those students who are so inclined. If their experience proves valuable, they are likely to maintain some loyalty toward the agency after their degree(s) are received. Employ promising student interns with a renewed effort to locate and employ minority students for work in the field with competent professionals. This has become more common in recent years between some agencies and universities, and some management agencies are contracting with universities to provide student interns to assist biologists in the field.
2. Again, if not already in place, develop for newly-employed biologists a meaningful orientation program of a pre-determined length with clear expectations. Working the first few months with an experienced and mentoring biologist in the field would be extremely beneficial to employees just out of school with no previous professional field experience.
3. Examine the professional/continuing education needs identified for both

new and experienced biologists and invest in programs to address these needs. This is another opportunity to work with your university faculty members and others to develop needed courses.

4. Establish and maintain entry-level standards for biologists which require a basic level of competence (e.g., TWS certification or other appropriate standards).
5. Involve representatives from various units within your agency, as well as administrators, in developing and implementing a strategic agency plan. Communicate this plan to all employees and key stakeholders to obtain feedback and ultimate buy-in. This also would help to overcome some of the institutional barriers within agencies. Share this plan with universities to help them determine future training and educational needs of students. This step would enable agencies to become more proactive in addressing both internal and external changes as well as emerging issues.
6. Maintain a dialog with employees and stakeholders about their expectations and future needs of the agency.

Considerations for Universities

1. Require all graduate students enrolling in an M.S. or Ph.D program to write a paper of five pages or less, before the end of their first term, which outlines their career goals and their expectations for the educational program they have begun. Then, prior to their graduation, have them review this paper and provide feedback as to why they were successful or not in preparing for career goals and whether their education and experience gained met their expectations. Maintain this feedback in a file and periodically review it with the faculty.
2. Meet with agency personnel whenever possible to evaluate the performance of recently-employed biologists who graduated from your institution, and encourage their assistance and involvement in the evolution of curricula and programs. Involve some of them in speaking occasionally to classes or presenting seminars and, if they have the time and interest, in teaching or team-teaching a course.
3. Explore ways to work with your department head and other natural resource departments to develop and team-instruct interdisciplinary and/or multidisciplinary courses that focus on land management including ecological and conservation principles as well as policy and regulatory constraints and strategies using real world case history examples.
4. Consider establishment of an advisory committee, made up of carefully selected personnel from management agencies, organizations, industry, and key community stakeholders, to help identify the changing capabilities of graduates and to advise, market and support the programs of the department.

5. Include as an essential element of the requirements for graduate students that the results of their research be published in either a media article or an extension-type publication. The article should define how their research contributes to the knowledge and/or management of wildlife resources on the land.
6. Continue to recruit minority students; encourage all students to take advantage of the opportunity to gain field experience; and maintain maximum flexibility and support for having them attend and make presentations at professional meetings.

Conclusions

I will wrap this up by providing an assessment, based on references from respected colleagues and my own professional bias, of where the profession stands presently and where it will need to be in the future. In terms of our educational system, I cannot disagree with many of the conclusions reached in the paper presented 10 years ago at this conference, or in the other references cited. However, in all fairness to both our educational system and to wildlife management agencies, I believe evolution has occurred in the past decade. Yet serious challenges remain. The changes in demographics that are underway identified by Hodgdon (1999), pose some significant challenges for fish and wildlife managers (e.g., "Impacts to fish and wildlife habitat through fragmentation, degradation, and loss; people's changing perceptions of fish and wildlife management; and shifting cultural values involving wildlife. But changing perceptions and cultural values will bring us the most severe challenges."). Later in this same paper, Hodgdon stated, "What seems to have been de-emphasized in many university programs is preparation in the skills, outlook and attitudes needed by managers of natural resources and people—the application side of wildlife management. Universities and employing agencies share the responsibilities of restoring management activities for both wildlife and humans to the curricula. It's a two-way street and partnerships are needed to help ensure that the types of new skills needed by tomorrow's managers are being addressed as part of the university curricula today."

Yet, I think most of us would agree that wildlife students today are obtaining a more comprehensive education and are better prepared to work with new and emerging technologies than those of us who graduated 20 years or more in the past. What they may be less skilled in, however, are the practices of "hands-on" management, field application of land and wildlife techniques, and the inherent "naturalist" experiences that those with direct ties to the land may have obtained. I am, however, impressed with the enthusiasm, insight and presentation skills of many of the students we visit with when conducting reviews and those attending and participating in professional meetings. At the same time, I have concern about the seeming decreased interest by undergraduates in wildlife management and growing interest in conservation biology. It will be important to ensure that they understand the values and benefits of both and where they overlap. It is obvious, however, that there is a significant change in philosophy taking place in management agencies and in university faculty. Those with a traditional consumptive-use philosophy are moving out of the work force and being replaced by those with a stronger preservation and protectionist philosophy. There will be serious consequences unless we work to balance these opposing philosophies. The major challenge for both management agencies and university wildlife programs is securing and maintaining appropriate funding levels in the face of declining traditional public support. Unless university wildlife departments learn to do a better job of translating the research they conduct and making its benefits known to the citizens and agencies of their state, they will become more and more dependent on extramural-directed research support and less able to compete for limited university research dollars and faculty positions. On the side of state wildlife management agencies, unless the pending Conservation and Reinvestment Act (CARA) and/or other federal and state legislation provides some mechanism for additional funding and developing a more diverse and supportive constituency, their support base will surely decline. If CARA funding becomes a reality, it could potentially double the funding base of some state agencies and enable them to expand both their programs and their diversity of clientele support.

Other significant challenges include: increasing encroachment of urban and suburban development on wildlife habitats and resulting increases in human/wildlife interactions; decreasing access for recreationists on private lands; and an increasing distrust by segments of the public for state and federal government management agencies and their programs.

However, I've always been an optimist, and I believe we have before us a great opportunity to expand our base of public support. I am confident that if we take the necessary steps to develop a vision for the future and appropriate strategies to achieve that vision, wildlife programs and our chosen profession will continue to survive and serve both society and the wild, living resources we care so deeply about. I concur with Hodgdon (1990 that, "We must participate actively and fully in designing future wildlife management programs and uses that will provide both the desired public benefits and the long-term protection and sustainability of the resource base."

I have great confidence in our profession and my colleagues present and future. I offer no apologies for the past accomplishments of our profession, and have great respect for our predecessors, who succeeded in making our wildlife management programs the best in the world. In my opinion, the future of our profession holds great promise. There are currently more biologists employed than at any time in the past, and the need for competent biologists in the future is not likely to diminish. I concur with Berryman (1995) that, "The opportunity to make a worthwhile and necessary contribution to the well being of fish and wildlife resources and their habitats will always be a part of the American fabric for the enjoyment and use of future generations. It is a rewarding experience." I close with a question and a wish. The question is, "Are we prepared for the fundamental changes in our profession that are and will be occurring in the future?" I really can't answer the question, but my wish is that we do not forget that science is not without conscience; and even if we continue our reliance on good science, increase our knowledge, and find new funding sources, we must not lose our passion for wild things and wild places.

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Preparing and Hiring for the Future: Are We Playing for the Short or Long Term?

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To address adequately the question posed in this session, both "today's" and "tomorrow's" resource agency needs must be considered. It is always with some peril that one predicts the future, but I believe two issues will drive resource management agencies over the next twenty to thirty years. One issue will be an increasing demand on wildlife resources from various interest groups with widely divergent philosophies and lifestyles. The second, and parallel, issue will be the availability of information and how agencies use it to facilitate the resolution of resource use conflicts. Together, these issues will present challenges on the one hand for academic institutions to adequately prepare professionals with an appropriate mix of values, philosophical breadth, critical thinking and technical skills, and on the other hand, for resource agencies to recognize what they need.

Some Historical Context

During the 20th century there was a significant change in focus of government agencies in dealing with wildlife conservation issues. This change has progressed from one of concern primarily with providing sufficient numbers of game species to one of broader conservation concerns for wildlife species and habitat (Hunter 1990). During this same period, there has been a continual change in the variety of interest groups concerned with wildlife conservation. In the early to mid-century, the primary interaction of government agencies was with hunters and their associated organizations. From then to the end of the century, the number of interest groups has increased. Many of these groups have widely different philosophies about wildlife conservation, from complete protection to regulated harvest. Many of these groups have large and entrenched economic interests. Given these interests and the diversity of the publics concerned with wildlife conservation, there likely will continue to be a diversity of interest groups and an entrenchment of philosophies with which government agencies will need to interact.

Because one of the roles of government is to develop and implement policies for conservation, wildlife professionals need to be adept at dealing with these divergent interests. Interest groups advocate particular points of view to government as a means of influencing policies and regulations. Wildlife professionals cannot engage in advocacy for any one point of view. Although professionals will always have a particular point of view because of their background and personal philosophy, analysis of policy alternatives and subsequent legislation and regulations cannot be fair to various publics if professionals are seen as advocates for particular groups.

Given the diversity and entrenchment of interest groups and the continual need to provide access to resources to serve the public there will continue to be a need to facilitate and regulate access to resources. Consequently, it is necessary that professionals come to the job with an exposure to various philosophies of resource use and an understanding of the dangers of advocacy for a particular interest group. Their job will need to revolve around facilitating an objective analytical approach to examining potential long-term effects of various resource use alternatives. This approach is necessary to provide government politicians with sound advice and a transparent presentation of evidence supporting alternative uses and impacts. Such advice may not be followed for a variety of reasons; politicians may decide that particular activities are detrimental to conservation but allow them anyway. These situations occur all of the time and in every jurisdiction (Pister 1997). Our job is to provide sound analytical advice about the potential effects, both positive and negative, and not be seen to be advocating a particular position.

Science and Public Opinion

I often hear the lament that such-and-such advice is based upon sound science so why did the policy not reflect my/our sound science. Well, often the politics and public acceptance of the sound science does not win the day. Sound science can also be in the eye of the beholder. This really touches on the issue of confusing science as a process with knowledge as a product of the process. Academic institutions often contribute to the confusion and agencies foster it. An obvious current example, is the increasing debate about genetically modified foods.

On the one side we have scientists from the agri-food industry advocating that their science (product) cannot find any evidence of impacts on health to people or to the environment. On the other side are scientists and various interest groups who are concerned about the unknown impacts. Ironically, both groups may be correct. Science (process) never has and can never predict the future impacts of particular findings because it can never prove anything; it can only disprove any given alternative explanation. Thus, those scientists advocating genetic modifications based on current evidence can argue their science (product) has not provided any evidence of health or ecological impacts, but they cannot say this will not happen in the future. Arguments on the other side also fail for the same reasons. More reliable knowledge (product) (Romesburg 1981) can be gained only by a rigorous evaluation of alternative predicted effects. However, in democratic governments, it is public opinion that wins the day and public opinion may not give a hoot about who has done the best "science," and has the most reliable knowledge.

Regardless of the intensity of debate and the evidence on one side or the other, at the end of the day there will always be uncertainty. This applies to the genetic modification debate as it does to issues on resource use. In the area of resource use activities, however, the degree of uncertainty can be reduced if wildlife professionals can work with interest groups to facilitate an understanding among the various groups an appreciation of the long-term consequences of various alternative resource use activities. This approach is termed adaptive management (Holling 1978, 1995, Walters 1986). There is a growing interest by resource management agencies to engage in this approach to resolving resource management conflicts (Taylor et al. 1997). There is now recognition and acceptance that resource users, particularly industry and business, must be engaged in helping to address sustainable resource management issues (Daily and Walker 2000).

Thus, training of wildlife professionals must include exposure to the conflicts of resource use and the means of facilitating the reduction of uncertainty. This training will need to include a broad undergraduate education in the arts and sciences to expose students to a variety of points of view and to develop skills in critical thinking. An overriding context for agencies and educators will be the challenges and opportunities presented by the access to and dissemination of information.

Playing with Information Systems

It is rather trite to suggest that the sophistication of computing systems has changed our professional and daily lives. Yet, this single technology has shaped the way in which we do our jobs. Moreover, at this point in time it is difficult to argue that it will not continue to be a dominant influence in the future. My own agency has invested heavily in information technology, particularly in providing spatial resource information. To enable the acquisition and dissemination of spatial resource information, we have hired a cadre of people with these particular skills over the past five years. Many of these people have degrees in disciplines other than wildlife biology such as geography. Some obtained skills in information systems through post- graduate training at technical institutions that specialize in training on geographic information systems and other related information systems. But will these skills be needed in the future?

Computers have become user-friendly at an accelerated pace. This trend has occurred primarily through the development of sophisticated software that allows users with a minimum of training to use the software to manipulate and use large data sets for a variety of analytical purposes. Even such uses as word processing have undergone huge changes in simplicity of use. I expect that the software we use now for a variety of information systems, especially geographic information systems will undergo similar user-friendly developments. This change already has occurred with various GIS packages (e.g., ArcView GIS™, Environmental Systems Research Institute, Inc.). Consequently, it may be only a few short years before the manipulation of spatial data will become as easy as using any of the popular word processing packages now available and current GIS skills may well become obsolete.

Certainly, the trend in increasing amounts of information, the availability of information and the dissemination of information globally will provide opportunities and problems that we cannot now envisage. However, I worry that among many who are leading the development of information systems there is almost a blind faith that its availability will automatically provide answers to the sustainable management of natural resources. Attendant with this mandate is the assumption that data-rich, information systems will be all that is needed for sustainable management. We may eventually reinforce the old adage; we are drowning in information but are thirsty for knowledge!

Well, there are tons of data and more to come. It is not data that are important to solving resource management problems. It is the question(s) that is important, followed by the identification of the resolution and grain of data necessary to answer the question(s). The profusion of data will create a maze that will be difficult to escape. Having more data will not lead to clearer answers unless those answers are founded on a critical path of developing a clear set of questions and hypotheses. This need to differentiate between questions and data will present challenges to agencies in attempting to collaborate with users in resolving resource use issues (Walters 1997).

I suggest that what we have now are not so much information systems as they are 'mere' data storage and dissemination systems. Information systems used by leading edge businesses include not just data, but analytical and diagnostic tools that can be reliably used for decision making (Drucker 1998). The current emphasis by many agencies, including my own, on developing spatial resource information constitutes little more than providing data. Although this effort reflects the first steps in developing an information system, we are a long way from having reliable knowledge. By definition we need to distinguish between information systems which are underpinned by reliable knowledge and data management systems which house data only.

I believe for many agencies, the move to a more robust information system is the development and application of models for resource planning purposes. Considering the ease with which software can be used today, almost any of us with even a rudimentary knowledge of software, can develop a reasonable model, (or we might carefully buy one off the shelf). It may be a bit careless to generalize, but most agencies and most projects these days associated with information systems are all about building models. The problem is that developing a model that works on the computer is relatively easy, but evaluating the effectiveness of model outputs is expensive and time-consuming (Conroy 1993). Consequently, in many cases, we are some distance from having reliable models that can be confidently used by agency staff and resource users and thus embody the ultimate ideal of an information system that delivers reliable knowledge.

There can be no doubt that technology provides a powerful means of looking at the world in a variety of perspectives. One of the many powerful uses of the technology is to conduct simulations to examine alternative management approaches and to examine tradeoffs (Walters 1997). This capability accompanied with the increasing availability of data will open new avenues in the future. Unfortunately, in many cases, the short-term use of models seems to be to provide prescriptions for solving a management problem without the attendant attention to its validity in the real world (Conroy 1993). Given the familiarity with computer technology of students entering universities now and in the future, there is a real danger that they will believe the computer is reality.

Playing for the Short Term

A recent trend has been for business to criticize universities for not producing people with skills that are of immediate use to them. We have seen a trend to hiring of people from technical colleges to fulfill this demand. Governments have not been immune from this temptation. But we also have recent evidence of big business realizing that these sorts of skills in a variety of fields are not necessarily going to be the skills necessary to increase their bottom lines. It is quite likely that wildlife agencies will come to the same realization, because these technical skills may not be the enduring skills that governments will need to deal with multiple resource management issues in the future.

Are we confusing analytical skills necessary to use data management systems, whether they are spatial or non-spatial, and the critical thinking skills necessary to evaluate among alternative explanations to understand and predict the reaction of ecological systems to our management interventions? I believe we are confusing them because we are focusing on our immediate needs, and not on the long term. The increasing emphasis on pseudo information systems, as opposed to reliable knowledge systems almost repels us from seeing the proverbial "forest for the trees."

Our current emphasis on hiring people with the necessary technical skills is a simple short-term necessity. We as resource management agencies are under extreme pressure to provide information and answers to resource management questions quickly. The answers however, may not have much endurance unless they are based on reliable knowledge (Romesburg 1981).

Playing for the Long Term

Governments do not and cannot hire wildlife professionals as one size fits all. There are many types of jobs that emphasize particular talents and skills. These skills range from those that are involved in consultations with users of wildlife resources, to those involved in planning, policy development, regulations, and compliance. But what should universities emphasize to prepare graduates for these jobs? I do not believe we can accurately predict which particular skills will be needed in 10 to 20 years, but I believe we know which skills will have endurance and be adaptable to specific skills needed do deal with any particular situation over the long term.

The parallel influences of a variety of interest groups with philosophically competing interests and the accelerating dissemination of data without the attendant reliable knowledge systems will require talented wildlife professionals who are adept at dealing with both people and information (reliable knowledge) in the interests of wildlife conservation. Both interest groups and government agencies are and will continue to be guilty of misusing data. Availability of data will also allow an even more widespread use of experts outside of government by interest groups to favorably portray their view. If wildlife agencies are going to play in the wider global game, and mediate resource use conflicts they will need highly qualified people that can hold their own with other experts. Short-term skills will not likely have any long-term endurance in this game.

The long-term game will be played successfully by professionals with creativity, critical analytical skills, a broad education, and a sound understanding of ecological theory. All of these attributes are the cornerstones of a good professional education. They are also attributes of good universities that have not strayed far from these underlying foundations of a good education. I believe government agencies will need these long-term skills more so in the future. I cannot advise academics how to balance courses to fulfill these needs. However, I urge you to resist trading off short-term technical skills for those skills that will be of value to wildlife agencies in playing the long-term game even though many agencies may have difficulty identifying their future needs.

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The Preparedness of Entry-level Natural Resource Professionals in the Forest Service

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Placement of qualified graduates from academic institutions into available entry-level jobs in the Forest Service continues to be a challenge. The personnel needs of the Forest Service are changing at a faster rate than natural resource schools can shift their curricula. There also seems to be an inherent tendency for schools to maintain the traditional programs of focusing on functional expertise. We in the Forest Service have contributed to this partial disconnection by not communicating our needs in a definite way. Also, we have not been timely with communication of our needs.

Functional expertise is compatible with entry-level needs of the Forest Service. Graduates applying for jobs requiring particular knowledge, such as silviculture, biology, and ecology, should be sufficiently educated in these fields. After all, any employer would expect newly hired employees to have the basic skills for which they were hired. However, now there are other attributes sought after that if present will assure that the employee will have a higher likelihood of success. Also, some jobs require skills and knowledge not previously needed in the Forest Service.

An associated personnel problem experienced in the Forest Service over the past several years is a reduction in the government work force. This reduction left many Forest Service units short of help in key jobs. Thus, the Forest Service is now playing "catch up" in certain skill areas. Additional concern focuses on the aging work force, which could lead a surge of experienced employees being lost to retirements over the next several years.

Competition from the private sector regarding pay and benefits is yet another complication. The unemployment rate in the United States is at an all time low, and it has become more difficult to hire the best into federal service. Due to rapidly changing demographic features of society, the Forest Service must work harder to achieve its outreach and diversity objectives. Knowledge of natural resource careers among many people is often insufficient. Minorities and women continue to be underrepresented in the Forest Service. A partial explanation for this deficiency is the limited exposure students get to information about natural resource careers. This limitation leads to a smaller candidate pool of graduates trained in natural resource areas.

A point of deliberation over what level of education to require arises when advertising professional positions within the Forest Service. This deliberation is also a major concern of students who must decide whether an investment in time and money to achieve an advanced degree is warranted given the expected advantage once in the workplace. Generally speaking, a masters degree differentiates the best applicants pursuing most advertised professional positions in the Forest Service. Even though not a requirement in many cases, competition for entry-level professional jobs is keen enough that a masters degree will normally give post-graduates the advantage in getting hired. A masters degree also can lead to a higher likelihood of promotion at a faster rate.

For positions specifically involved in the Forest Service research branch, a doctorate degree is strongly advised. For promotion within the research ranks, one's reputation as an expert is important. A doctorate degree is considered a requirement for a successful career in research.

While advanced degrees are not required, they often help employees rise to top positions in management. Subject matter experts are becoming more common in the management branches of the Forest Service (e.g., National Forest System and State and Private Forestry). For these specific positions in management, a doctorate can result in a career advantage for promotion.

Overall, successful professional employees enter the Forest Service with a formal degree and then continue skill and knowledge development throughout their careers. The continued education program is a combination of employer-conducted education and formal continued education classes provided by academic institutions or targeted contractors.

"Self education" is becoming more important for the successful career professional. Taking on personal responsibility for advancement has become a necessity for people to "keep up." Computer literacy is an example of one area where many employees spend their own personal time taking classes or are involved in self-instruction. No longer can one only depend on the employer to satisfy all of one's professional advancement needs. Some call it "lifelong learning." Learning a foreign language, or several, is becoming more important as the customer base of the Forest Service further diversifies. An example is the predominant customer base that is evolving in the West associated with Hispanic communities. Many of our Forest Service units in the West need employees who can speak and understand Spanish. The Forest Service also could do a better job in providing incentives for self-education, such as with more acknowledgment and awards.

A long-term problem experienced with entry-level employees is that, at first, many of them are not able to interact positively in a planning team environment. When confronted with trade-off analysis or questions regarding their input, they sometimes react defensively. Give-and-take in the forum of an interdisciplinary team does not come easy for them. Additional skills early in the career regarding teamwork and rules of engagement need to be learned. Universities and the Forest Service have a joint responsibility to help students and new employees with this troublesome area. Some schools have started teaching classes that bring candidates from differing degrees together to work on team projects. In this diversified environment, they learn how to share each others skills and work toward a solution that is acceptable to all. Preliminary training for entry-level personnel by the Forest Service also can help new employees develop the skills and attitude to be more productive when thrust into a real team project.

The mix of disciplines within the Forest Service ranks is changing. Included below is a partial list of the traditional positions in the workforce: foresters, engineers, hydrologists, mineral specialists, silviculturists, biologists, personnel specialists, soil scientists, landscape architects, ecologists, and fire specialists.

Those traditional positions satisfied the obligations interpreted by the agency, as well as a responding to public interest. The following represents examples of the new disciplines that are commonly now being sought after to respond to current and foreseeable needs, and some of the traditional disciplines receiving increased emphasis: social scientists, public affairs specialists, economists, business managers, geographic information specialists, financial managers, entomologists, information systems specialists, urban foresters, computer science specialists, watershed specialists, recreation specialists, and fire specialists (a continued high priority need).

These increased emphasis areas reflect changes in the Forest Service delivery of goods and services, and its fundamental responsibility of sound and scientific land stewardship. They also reflect the simple fact that the world is changing constantly, and as a result, individuals and institutions must adapt to succeed. For the Forest Service this means our future workforce needs are always shifting. For our employees (or would-be employees) this means their skill needs are always changing (i.e., lifelong learning is a must). What does the Forest Service need to do in today's changing world?

- Deliver what people need.
- Provide good value (high quality at reasonable cost).
- Offer excellent customer service.

Collaborative Stewardship

Consider the Forest Service's natural resource agenda—sustainability, watershed management, recreation, and roads. These priorities and the subissues associated with them represent mixed ownership issues. The Forest Service cannot independently achieve national goals in any of these areas. However, the agency can contribute to achievement of these goals through activities on national forests and exercising its non-regulatory authorities in assisting state, private and tribal landowners.

Participating in broad mixed ownership activities can be accomplished through collaborative stewardship. Collaborative stewardship represents an increased commitment by the Forest Service to work more closely with partners and communities. This increased commitment represents a willingness by the Forest Service to play less of an authoritative role, and function more as a convener and catalyst to help create community forums where many interests can help shape the outcomes of natural resource deliberations across ownerships. Examples include fighting forest fires, anticipating and responding to invasive species issues, forest health, urban forestry, large watershed restoration projects and striving to improve the sustainability of our nations forests and grasslands.

The broad-scale perspective is becoming so important that even interaction with other nations is getting more attention through the Forest Service International Forestry Program. Training and skill development in working with others collaboratively is a current area of emphasis. The goal is to have the Forest Service leadership become effective players in these domestic and global mixed ownership issues. A long-term leadership-training program is currently under development.

Business Principles

The Forest Service is putting considerable new emphasis on becoming more "businesslike." To help us, we have focused attention on a number of new (for us) areas in recent years. Following is a list of business principles that we have begun to discuss with Forest Service leaders:

- The world is market-driven and always changing.
- You must have vision, mission and values.
- Know your customer.
- To be part of the future, you must invest.
- Accountability is key.
- Make dust or eat dust.

We want our leaders to apply these principles to the work of the agency. To help in this pursuit, we have begun to focus on business planning. Business planning provides a disciplined way of applying the principles. An example outline for a watershed restoration business plan includes project description (the business idea); the customers and how they benefit; the competition (other ways of achieving the same benefits); measurement and accountability; communities involved; governance; marketing and sales the project team; risks and assumptions; timeline; and financial plan.

As seen from this outline, business planning makes us consider and engage the communities that have a stake in the venture. Business planning also helps shift our thinking from an entitlement mentality to an investment mentality—a fundamentally new way for a government agency to think.

Marketing

First, let us be clear, marketing is not advertising, and it's not huckstering. Rather, marketing is "Finding out what people want, and delivering it to them within our capabilities." This responsibility becomes fundamental to an agency that has begun to think about investments rather than entitlements.

A focus on marketing leads us to several actions that are not necessarily traditional for the Forest Service. First, we must do research about customers, their wants and needs. This is quite a different kind of research than we have focused most attention on in the past. Second, we will pay an incredible amount of attention to the customer. And this is not static, so it's a constant activity. Third, we must be nimble—that is, adaptable in an appropriate time frame to the changing needs of our customers.

Entrepreneurship

Our focus on business principles and marketing leads us naturally to this third new area of endeavor. We want to engage the wisdom of the marketplace in our decision making. Taking a lesson from the business world, we know that market forces can help us better allocate resources to do our work. Freeing our employees from the bureaucracy—unleashing their entrepreneurial spirit—more fully engages their wit, ingenuity, creativity and drive. In many ways this embodies the spirit of America; we want to bring this spirit into our organization.

Conclusion

How are we putting these "new" ideas into action? We are offering a business principles class for Forest Service leaders. We developed and taught the first two classes last year, and we will make it a part of ongoing leadership development.

Business plans are becoming a normal part of some of our work, and more so all the time. This year, we have undertaken a number of large-scale watershed projects in collaboration with many partners. All these projects are proceeding on the basis of a business plan. The Modoc National Forest has developed a prototype business plan for their forest. No doubt, more forests will follow.

We have completed an "Internal Enterprise" experiment in the Pacific Southwest Region and Station (California). Our two-year test has proven that entrepreneurship and business planning work in the Forest Service. We are intending to expand the concept to other regions.

We have formally learned more about marketing with a marketing research group. For the past 20 months, this Forest Service team has learned the value of and the how-to of marketing in the Forest Service. We are applying the marketing ideas to projects in two recreation-related areas this year (Sedona and Oregon Coast).

Most recently, we have formed a Quality Council to institutionalize these ideas. This council will ensure that we become as good at our business management practices as we always have been at our natural resource management practices. We have come to realize quite recently that the Forest Service agenda is composed of natural resource management, business management and human resource management.

The world is changing, and we resource professionals know that to thrive all things must adapt to changing conditions. We will be the first to say that the Forest Service is not, should not be, and will not be a "for-profit" business. But, within our mission we can better serve the public by incorporating some of the good ideas from the world of business. As an agent of the people of the United States, we are obligated to make wise investments in the future of our natural resources—to be more businesslike. Our workforce must blend human resource skills, business management skills and natural resource management skills to a degree that we have never before imagined. Effective training and management of our work force is the means to achieve that proficiency.

Evolving State Agencies, University Curricula and Wildlife Students

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The session topic raises the question: Do young wildlife professionals fulfill the needs of management in today's resource agency? The fact that the question is even posed suggests that there is some concern with the profession that they do not. To even superficially address the topic requires answers to the questions: Who are our young wildlife professionals and how are they trained?; and what are the management needs of today's resource agencies? My session colleagues have addressed U. S. (Regan 2000), Canadian (Baker 2000), and agency (Janik 2000) perspectives of needs faced by today's resource management agencies and how academia has responded to these needs (Messmer and Conover 2000). Miller (2000) addressed the important, related question of whether or not today's agencies know what to expect from young professionals. Also, it is important to consider the opinion of students (Caudell 2000) in order to adequately address the question posed.

The North American Wildlife and Natural Resources Conference has long been an important venue to address the topic of training professional natural resource managers. My presentation is a historical review of the path we have traveled to get where we are. I will present few original thoughts, but instead will point out what I believe to be important insights of those who have addressed similar and related topics before me. I will briefly trace the origin of our state agencies, the history of how university curricula have evolved in response to the perceived needs of our profession, and then address the "evolution" of those who aspire to join the ranks of professional resource managers.

The Origin and Evolution of Natural Resource Agencies and Their Training Needs

First, how did we begin? State agencies that today are staffed largely by professionals trained in our nation's colleges and universities had their origins in the late 19th and early 20th centuries; and early wildlife managers were hardly a cadre of formally trained professionals! As the 19th century drew to a close, state agencies were born in response to growing concern among conservationists for diminishing wildlife resources.

While certainly not representative of all, the evolution of Illinois' state agency illustrates a course taken, changes over time and insight into trained personnel needs (the following abbreviated history is compiled without citation from unpublished archives, files and reports; several editions of the Blue Book of the State of Illinois; or agency annual reports). The Illinois Game Commission was formed in 1899 and provided for one commissioner, 22 wardens (one from each congressional district), and one or more deputies from each county. In 1913, the game and fish commissions were merged in response to reputed "waste, inefficiency and mass corruption." The new Game and Fish Commission was charged to be more than an enforcement agency; it also was given the duty to protect game and fish and use such artificial means "which were found to be effective" to increase the supply of both. This agency lasted only until 1917 when it was disbanded because of reported lack of efficiency. The agency was replaced by a Division of Fish and Game established within the Department of Agriculture. In 1925, the Department of Conservation was created "to serve the sportsmen who made its conception possible and upon whom it must rely for its perpetuation." The new agency was composed of a general office, a division of law enforcement, and a division of fish and game. The latter division had a strong focus on propagation and staff learned their trade mainly from experience and apprenticeship. A division of forestry was added the following year; and in 1941, separate divisions of game and fish were created and a division of education added. Educational requirements to staff the divisions of this agency are not known; however, a Conservation Officers Training School was established in 1943, the same year it became a requirement for conservation officers to pass a civil service examination. One can easily imagine that educational requirements for personnel to staff the agency were not rigorous before this point in time. Various reorganizations occurred over the years as the agency became larger and more complex. In 1971, the Division of Game Management became the Division of Wildlife Resources with two sections (management and survey and investigations). By this time wildlife division staff were reasonably well-trained; most held undergraduate degrees in wildlife or related disciplines, and some held a Master's degree. Other reorganizations followed through the 1970s and 1980s, but an entirely new agency was created in 1995 — the Illinois Department of Natural Resources. The agency is large and complex; it consists of 11 offices and 11 boards and commissions. The Division of Wildlife Resources is now one of five units within the Office of Resource Conservation and clearly is no longer the central core of an agency just devoted to managing wildlife resources.

The mission and purpose of state agencies as they evolved defined the needs for trained staff. Protection of wildlife and law enforcement were the initial driving forces. As agencies developed, the need for technical expertise soon became apparent. Following decades of emphasis on technical training, the era of public relations/human dimensions emerged demanding a new set of training and skills. The Division of Wildlife Resources within Illinois' agency illustrates where we are today. The staff is better trained than ever in the agency's history, but still it may not be trained well enough. According to the division chief, current and future wildlife managers and administrators need training in a variety of areas that historically have not been emphasized by educational institutional or agencies. Training needs identified include: communications, team building, consensus seeking, conflict resolution, understanding and practicing "biopolitics," public involvement, proactive planning, time management, personnel management, and budgeting (J. Ver Steeg personal communication: 1999). Clearly, the challenges faced by today's agencies and their staffs demand a commitment to continuing education.

The Evolution of Wildlife Education

Woolf and Adelman (1995) traced the history and approach of wildlife education in the U.S. that largely paralleled the evolution of agencies and their needs. The early agencies were headed and staffed mainly by political appointees whose typical activities were law enforcement, propagation and predator control (Swanson 1987). The training of these early staffers, if any, was derived through experience or apprenticeship. Leopold (1933:413) said that "In 1910, there were scarcely 100 trained foresters in the country. They held only a small percentage of the positions then open. The rest were held by untrained men." The universities did not respond with programs to provide qualified graduates until the 1930s (Swanson 1987). Poole (1971) credited the American Game Policy Committee chaired by Aldo Leopold (1929, 1930a, 1930b) with the success of the conservation movement. Among the far-sighted recommendations of that committee was one that gave birth to academic programs and the development of curricula in wildlife management (Leopold 1930a, 1930b).

The earliest training for wildlife managers was provided by scattered courses, such as curricula in forestry or zoology (Woolf and Adleman 1995). The publication of *Game Management* led to new academic offerings that embraced Leopold's philosophy and recommendations. Leopold's (1933) vision was perceptive and has withstood the test of time. He thought that graduate biologists should be able to use biology to solve problems, and he recognized that foundational studies such as economics, esthetics and policy were important. It is a credit to the vision of the wildlife management profession's early leaders and educators that the curricula they proposed incorporated courses related to the environment and land use as well as animal biology, and they recognized that communications skills were a necessary component of professional training (King 1938). The wildlife training programs that quickly appeared and evolved from Leopold's (1933) recommendations were far from rigid. Many educators agreed with Trippensee (1948) who thought that a single curriculum was undesirable because undergraduates rarely knew whether their careers would be in research, management or administration.

Although universities did not think of themselves as "trade schools," the prevailing educational models evolved in response to perceptions of the skills needed by the consummate professional wildlife biologist (and, of course, the agencies hiring them). The Wildlife Society adopted standards for certification, in 1965, based on the philosophy that education (a four-year program of study leading to a bachelor of science or higher degree) should include a background in biological, physical and social sciences. It is important to note that the concept of certification included more than the B.S. degree. The Wildlife Society recognized from its inception that job experience, in-service training and graduate degrees were essential for professional success and growth. University programs responded to this concept of wildlife education and often adapted programs to meet expressed needs of agencies, both state and federal (Anderson 1982, Schmidly et al. 1990).

Graduate training has played an important role in wildlife education since its inception as exemplified by the Cooperative Wildlife Research Unit program (Sparrowe 1982). However, Cooperative Unit programs are not alone in serving the wildlife profession. Hundreds of colleges and universities offer graduate programs in a variety of disciplines (conservation biology, landscape ecology, zoology, etc.) and they all contribute to the pool of talent available for employment by state agencies. In fact, Teer et al. (1990) bluntly stated that we should "Declare once and for all that a baccalaureate degree in wildlife is not the terminal degree for a wildlife biologist." Amen! Our next generation of resource managers will need a broad education, technical expertise and skills in the arena of human dimensions. We must recognize and accept the fact that our educational needs have evolved to the point that they cannot be achieved with a four-year baccalaureate degree; indeed, it is not likely that a defined period of graduate training will suffice. We have evolved to the point where the old concepts of in-service training, continuing education, and lifelong learning take on new meaning and importance.

We have looked at yesterday and today, but what does tomorrow hold? I believe we are at a crossroads, and the educational paradigms that have served us so well must change. Woolf and Adelman (1995:133) stated "As educators, we must recognize trends and proactively provide the education needed." Indeed, universities are undergoing introspection in response to changing technology and public concerns (see Kellogg Commission 1999). The commission's report challenges us to use new information technologies to enrich learning by tailoring instruction to societal, organization and individual needs. They further challenge us to equip students with higher-order reasoning skills required for lifelong learning.

The new technologies are already upon us and are driving new educational paradigms; witness distance learning. Advances in technology and pedagogy have potential to revolutionize the type of education agency employees receive, both as a foundation for lifelong learning and in-service and continuing education. Consider also the power now available (via e-mail, Internet, etc.) to more effectively communicate with and educate constituents. There already are a variety of wildlife-oriented distance learning programs being offered by some universities (Cross 1999), and more are sure to follow. The information age and opportunities for distance learning will surely lead to changes in wildlife curricula and how tomorrow's professionals are trained and kept abreast of new knowledge as it emerges.

The Evolution of Wildlife Students

Are today's students different from yesterday's? Of course they are, and why not? They are a product of a society with changing demographics, life styles and values. First, we are an urban society in stark contrast to that in the early 1930s when our first wildlife programs were born. The students who attended those early programs were from families that struggled (or were still struggling) with effects of the Depression. The young men who attended school, if not from the farm, were mostly rural; and hunting gear, traps and fishing tackle were among their possessions. The war years intervened and those experiences and the post-war opportunities of the GI Bill, produced a whole new set of students to pursue careers in wildlife management. Wildlife programs and their curricula were founded on Leopold's game management philosophy, and the agencies of the day served the needs of game animals, animal habitats and the recreational hunters and trappers who paid the bill. So it should be no surprise that students interested in training for a career with these agencies were those who shared these interests and values, thus they were largely rural and had a passion for fishing and hunting (Reeff and Angus 1994).

But times changed, and an increasing proportion of the U.S. population has begun to live in metropolitan areas (57 percent in 1950 increasing to 78 percent in 1990) (Reeff and Angus 1994). Demographic changes led to changes in the traditional agency constituencies and, likewise, the students who pursued careers in wildlife management. For example, the Cooperative Wildlife Research Laboratory at Southern Illinois University graduate program has supported ~300 students since its inception in 1950; 4 percent of the first 50 students (through 1962) were female, whereas 32 percent of the last 50 students (since 1991) were female. This program is not unique; Craven et al. (1996) reported that the student body in the Department of Wildlife Ecology, University of Wisconsin, Madison was primarily male with a rural heritage in the 1970s, but was more than 60 percent female with urban/suburban origins by the early 1990s. Our students (who aspire to be tomorrow's agency workforce) tend to "reflect America" in the sense they are more likely to be female, come from a suburban background and have a limited interest in (exposure to) hunting (Reeff and Angus 1994). Even with these dramatic changes, our students still do not reflect the multicultural composition of today's society and the complex array of constituencies who are (or may become) concerned with what the agency does or how it goes about doing it.

Finally, it is important to emphasize that, no matter who they are, students are no longer representative only of the traditional constituency of hunters served by state agencies. They are far more diverse and complex, and hunting is declining in interest and importance among them. Today's student is likely to have (or seek) expertise in subject areas and application of tools such as statistics, modeling, remote sensing, GIS, GPS, and others. Increasing numbers of students are aware of the need for communications skills; they are sensitive to the need for "people skills," and embrace the role and importance of "human dimensions" in resource management. But fewer value, seek or possess the field savvy and outdoor skills that were hallmarks of the previous generation of wildlife students. To the degree that my students reflect the entire population (and I believe they indeed are typical), few wish to do research on game animals or related topics in contrast to the number interested in endangered species, nongame wildlife, restoration ecology, etc. Do not confuse this statement with a value judgment, it is simply acknowledgment of what is! As the students who are products of an increasingly urban society seek to pursue studies leading to careers as wildlife biologists, more will be of the "armchair" variety. Understanding wildlife/habitat relationships increasingly will be gained from computers and their software that blend remotely-sensed data within models, rather than from muddy boots and the insight gleaned in the pursuit of game. Most Americans will lack experience with wild nature and instead will experience it through an urban epistemology (Muth et al. 1998); so too will vast numbers of tomorrow's wildlife students.

Long Live Leopold, But His Agency/Education Paradigm is Dead!

Resource management agencies have changed, but has that sunk in? Amend and Gasson (1996) pointed out some new realities facing fish and wildlife agencies. These new realities are a consequence of changing cultural and social values that have also influenced scientific thinking. Perhaps more importantly, as a consequence of these changes, the "North American Conservation Model" that has served us so well for almost 100 years is no longer dominant (Muth et al. 1998). The foundation of that model, formalized with Leopold's committee recommendations (1930b) and landmark textbook (Leopold 1933), focused on management of game species and their habitats. In the early evolution of state agencies, the North American Conservation Model dominated agency structure and policy. The students of that era learned from curricula designed from that model, and they, in turn, staffed the agencies and perpetuated policies and a management philosophy that perpetuated the model. Recreational hunters who pursued game animals for sport joined agencies as allies with a common cause. They were a "natural" public that shared values with the agencies and benefitted from their actions. This constituency of consumptive users provided the bulk of funding to operate agencies, and they benefitted from an agency policy emphasis that was distributive in the sense that the agency provided goods and services to this public (Mangun 1992).

The organizational structure of state agencies varies from relatively homogeneous game commissions to multifaceted natural resource agencies with broad missions and structures reflecting that diversity (Wildlife Management Institute 1997). The mission and structure of an agency determines, to a large degree, the importance and influence of the North American Conservation Model in formulation of policy and management emphasis. Although the North American Conservation Model persists, and even dominates some agencies, it shares the stage with models that emphasize biodiversity, ecosystem management, endangered species, and non-game wildlife. Similarly, the tenets of wildlife ecology and management are increasingly challenged by those who practice and advocate the disciplines of conservation biology and landscape ecology.

Craven et al. (1996) thought that most wildlife professionals will interact with hunters and hunting at times during their career and agreed with Ledford (1995) who thought that biologists who knew nothing about hunting and hunters would be at a disadvantage when attempting to establish credibility while carrying out professional duties. This is likely true, at least for biologists working in many agencies today. I wish I could believe that most wildlife professionals in tomorrow's agencies will have duties that require interaction with hunters and hunting, but I suspect that likely is wishful thinking. Instead, I agree with Muth et al. (1998) who perceived the profession to be at a crossroad and recognized that the paradigm that formerly guided wildlife management is now only one of many. However, I continue to share the view of some wildlife administrators (J. Ver Steeg personal communication: 2000) who believe that biologists who understand hunters and hunting will be very important to agencies for some time to come; albeit, they may not, or need not be a major component of an agency's staff. Whether or not professionals who can empathize with hunters and share their values will be an important component of tomorrow's agencies is subject to debate, but so long as hunting persists, so will the need for such people.

Universities and Their Students: Up to the Task?

I have looked back and ahead as well as at today, but will conclude with a final look at the session's question: Do our young wildlife professionals fulfill the needs of management in today's resource agency? The question is important and our profession and agencies are not alone in posing such a question. Many today are questioning the relevance, values and structure of our system of higher education, and how well it trains people for a given profession (Noss 1997). How we define success is questioned; are we merely training students, or do we more appropriately educate them (Orr 1999)? I believe that universities are producing both well-educated and well-trained young people to meet agency needs, but that task is becoming more difficult as demands for expertise increase. Also, I submit that what some agencies want or expect may not even be realistic, even for those trained at the masters level. I profess that agencies will have to join universities as full partners to make sure that today's students meet the challenge as young professionals and be able to meet agency management needs. Agencies must clearly define and identify their needs, and learn to select the best qualified people for positions. They must make internships and other opportunities available for students to gain experience and benefit from mentors; and those in higher education must effectively incorporate these opportunities into curricula. Also, agencies must accept the need for timely, relevant and rigorous in-service training; and universities must use the latest technology to meet those needs.

I recall a conversation with a colleague while attending a North American Wildlife and Natural Resources Conference several years ago. He indicated that when he graduated with a Bachelor's degree he was much better prepared to begin his career than are today's students. At first taken aback by his statement, I quickly realized it was not founded on arrogance, rather the simple realization that the challenges of our profession are such that we cannot expect them to arrive at work fully prepared to fulfill the agency's management needs.

I am a pilot, and I can remember the words of my first instructor who beat into my brain the simple truth that my newly acquired license was merely a ticket to learn; and to live, I would need to exercise good judgment while continuing to learn!

At the heart of the issue that led to the question is change, and the changes resource management agencies face take many forms and pose many challenges (Angus 1995). Our students are bright and capable and, for the most part, better trained than we were. They recognize the challenges and are eager to face them. My students recognize the importance of broad training that includes biological and ecological knowledge, supportive technical skills, and the ability to work as multi- and interdisciplinary teammates. Most, if not all, realize the limitations of Bachelor's degree in preparing them for more than a technician role with modern agencies. They have decided to attend graduate school to help them succeed in their chosen profession. They are idealistic and look forward, not back. In spite of the skills our students possess, agencies should not expect a consummate, polished professional to join their ranks, but they should expect well-educated, lifelong learners who can adapt to change and effectively manage our resources.

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Educating Today's Students for Tomorrow's Challenges in Natural Resource Management: A Student's Perspective

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Universities are places of higher learning that students traditionally attend to develop critical thinking and communication skills or to become better citizens. Some programs, such as medical or law schools, were modeled to prepare students for a specialized field so that once a student graduated they could enter that profession. Through the years, this model has become the prevailing mind-set for university education and for perspective students. Students now expect to be employable once they earn a degree in a particular field. Often, employers expect college graduates to have the skills necessary for their profession because they have a degree. But how are universities to accomplish this in the limited time they have access to students?

I primarily address undergraduate wildlife management programs in this paper because I believe graduate school can prepare students for the challenges of a professional wildlife management career. Generally, graduate students have the opportunity to take additional classes and gain valuable experience through research projects and are better prepared for the challenges of the wildlife profession than are undergraduates. On the other hand, undergraduate students have to meet the core requirements of the university before emphasis can be placed on developing the skills necessary for their profession.

But what are these skills? Historically, a prospective wildlife manager would learn how to restore and manage wildlife and their habitat, protect them from abuse, and manage the resource for recreational purposes (Sparrowe 1995). Today, communication, public relations, and people-management skills are important for the wildlife manager (Oglesby and Krueger 1989, Teer et al. 1990). The general public are becoming life-long learners, and as a result, they are becoming more involved in the management process. Wildlife managers must not only be able to develop a sustainable wildlife management plan, but they also must be able to sell those plans to the public and integrate public comment into the process.

Often university administrators must make a decision about which skills are to be emphasized, which will be ignored, leaving students deficient in the latter areas. University programs that emphasize mastery of technical skills may result in students with poor communication or interpersonal skills. So what can be done to better train students for the challenges of the profession? I address this question from personal experience as a recent undergraduate and current graduate student in wildlife management.

What Are the Needs of Wildlife Management Agencies?

Successful wildlife professionals need a broad range of both technical and interpersonal skills. Entry-level natural resource positions, requiring either a Master's of Science (MS) or Bachelor's of Science (BS) degree, generally require communication skills, public relation skills, technical/mechanical ability, and biological knowledge. In addition, potential employees with a MS degree should have program development, supervisory and evaluation skills, as well as increased knowledge levels (Oglesby and Krueger 1989, Adelman et al. 1990, Schmidly et al. 1990). In the past, mastery of technical skills was the primary emphasis of natural resources programs (Peek 1989). However, interpersonal skills are becoming more important in natural resource management.

In addition to these skills, students must possess a degree of professionalism (McCabe 1985). Gilbert (1971) 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." A professional should also be capable, tolerant, understanding, tactful, flexible, and honest. Other characteristics include self-analysis and criticism, dignity, the ability to communicate, devotion to duty, and a willingness to help others (Gilbert 1971).

Undergraduate Education Programs

With the broad range of skills necessary for today's wildlife professional, I do not believe that undergraduate programs alone can comprehensively train students for most challenges of their respective natural resources profession. Several limitations make it difficult to design a comprehensive program of study. The primary limitation is the amount classes a wildlife education program can require of its students to obtain a degree. As much as half of a student's credit hours are used in completing the university's core requirements. The remaining portion of the credit hours have to be divided among the skills necessary for the wildlife profession.

Some wildlife education programs do not focus on providing students with training for a job in the natural resources field after graduation, but rather provide students with broader knowledge that will make them better graduate students and future leaders in the profession. Some schools may have an ecological focus in their education and provide more theory and conceptual instruction or provide undergraduates with training in applied natural resources management. But is one approach better than the others? An agency needing technicians for fieldwork may prefer students with a mastery of technical skills or those with exposure to a wide range of skills so that minimal additional training is needed. An agency needing professionals with the ability to interact with the public may desire students with more communication skills. Natural resource professionals must have the ability to do the all aspects of the job. In my opinion, the ideal solution would be to produce a professional with all of these skills, but natural resource students may need to spend additional years of schooling beyond the BS to achieve this goal. Otherwise, a well-rounded natural resources professional must gain additional experience through internships, co-ops, employment, or graduate school.

Proper guidance is crucial in undergraduate education. Nobel and Silvy (1990) stated that the "fledgling professionals become the sole responsibility of the university faculty for a period of four or more years, during which they are nurtured to maturity." Students are shaped and molded by their advisors and other university faculty during this time. This is the key period for the faculty to impart the ideas of professionalism, as well as providing classroom instruction. Faculty have to understand the needs of wildlife agencies (or other potential employers) so that students can be directed to take the proper classes, especially if employment is desired in a particular agency.

How Can Universities Better Meet the Needs of Resource Agencies?

To improve undergraduate programs, students and advisors should be allowed to refine their course of study while meeting the basic skills necessary for the profession (Teer et al. 1990). Additional experiences with a particular agency or in various wildlife fields are also beneficial (Sparrowe 1995). There are several methods universities and agencies can use to produce graduates better suited for the challenges of the wildlife profession including specialized programs for specific areas of wildlife management or for a particular agency, internships and volunteering with agencies or on graduate research projects.

The Jack H. Berryman Institute (BI) is an excellent example of how universities can better train students for the natural resources profession. The BI primarily specializes in research, education, and outreach in the field of wildlife damage management (WDM). Students associated with BI have an interest and receive exposure in this field through classes, conferences, special symposia, and contact with WDM professionals. Because BI maintains an active partnership with wildlife agencies, which provide both funding and input into the program, these agencies know what to expect from BI-affiliated students. Consequently, BI is successful at placing students in the WDM profession. To date, 100 percent of graduates affiliated with BI are employed in the wildlife profession or are graduate students.

One potential dilemma for undergraduate students wanting to participate in a specialized program, such as BI, is that the program aligned with their interest may be in another state. Most undergraduates attend universities in their home or surroundings states due to cost and the influence of friends and family. Traveling to an out-of-state university if often not an option. However, student may be able to create an affiliation with these programs through distance education, exchange programs or summer internships. The Institute also has professional member throughout the country, which can give students outside Utah and the surrounding states opportunities to become affiliated with BI.

Historically, experience with natural resource agencies before professional employment began was essential to obtain employment. This experience was gained at annual meetings where prospective employers could meet students and by securing temporary part-time work or volunteering with natural resource agencies (Sparrowe 1995). I believe this is still the case. Natural resource agencies can develop internships programs that expose students to a wide range of experience and faculty should encourage students to take these opportunities. Occasionally, students participating in internships are utilized as cheap labor. Agencies should avoid this and take the opportunity to integrate students into various aspects of the agency, such as fieldwork and operations management. From participating in internships, I learned which direction I wanted my career to go. But more importantly, I learned which areas of wildlife management I did not want to work. The Institute instills this philosophy of active participation in its students. Students are encouraged to take advantage of every opportunity to attend meetings and participate in volunteer positions and internships. The BI encourages students to attend WDM meetings by providing financial assistance, often covering most of the expense of the meetings. Attendance at these meetings allows students to interact with professional, learn the latest WDM research and decide which aspects of WDM interest them.

Agencies also have to communicate with institutions about what classes and skills they believe graduates should have. Agency personnel may also offer to lecture or provide laboratory instruction for classes. Close working relationships between faculty and agencies will benefit students. By doing so, faculty can be routinely updated as to changes in employment opportunities, desired skills or volunteer opportunities. Agency cooperation is a key component of the BI's success. Agencies and industry leaders in WDM provide advisory input and funding into the operation of BI. Professors associated with BI gain insight as to the current trends and needs in the profession and are able to prepare their students for those challenges.

Conclusions

Colleges and universities are limited in what they can teach in the years they have access to students. It is unreasonable for employers to expect students to be able to meet all university requirements and receive all necessary instruction and experience to be a proficient natural resource manager. However, it is not unreasonable to expect students coming out of a natural resources education program that produce natural resource professionals to have basic skills necessary for gainful employment, the ability to become proficient in additional skills, and to meet the education requirements for profession certification in their respective fields.

Potential employers also have a responsibility for providing input to universities regarding its needs for future professionals. Employers should become more involved with the colleges they are most likely to get employees from and influence those programs to teach the skills they desire. Finally, programs such as the Berryman Institute, internships, and volunteer opportunities with natural resource agencies should be expanded. I believe these programs lead to graduates who have a firm understanding of an agency's requirements, employment opportunities, and the wildlife profession.

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Academic Response to the Needs of Natural Resource Agencies: A Case Study Involving Human/Wildlife Conflicts

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"I never think of the future; it comes soon enough."
—Albert Einstein

The university campus has traditionally served to link aspiring students with careers in natural resource management. Consequently, the university's role in preparing future professionals to meet the needs of resource agencies has been the topic of several special sessions at past North American Wildlife and Natural Resource Conferences. Most conference speakers generally agreed that too much effort was being directed toward programming students with the information and knowledge that would permit them to operate effectively in predictable situations where the goals were well-defined, understood, and widely accepted (Arnold 1976, Anderson 1982, Hoopes 1982, Miller and Schweitzer 1982). In reality, however, the environments in which contemporary wildlife managers live and work are anything but stable. In the future, social and political changes are likely to be even more drastic and less predictable. Thus, formal education programs conducted under a facade of stability may fall short of preparing young professionals to meet agency and society needs. To be successful in this dynamic environment, we argue that the natural resource management community, which includes academia, must have an inherent ability to recognize, monitor and adapt to changing human needs, socio-economic conditions and political trends.

Factors Affecting Natural Resource Management: Emergence of Human/Wildlife Conflicts

Major factors that have been previously reported in the literature as affecting contemporary natural resource management include: continued habitat loss and fragmentation in the face of increasing human populations and per capita consumption of natural resources (Daily and Ehrlich 1992, Houghton 1994), increasing conflicts regarding resource use and management (Hoopes

1982), renewed public awareness and interest in non-economic resource values (Duda and Young 1994), and escalating human-wildlife conflicts (Conover et al. 1995, Conover 1997a, 1998).

We believe that the increasing frequency of human/wildlife conflicts may offer agencies the greatest opportunity to communicate with a wider range of stakeholders than at anytime in their history. The area of human/wildlife conflicts, more particularly wildlife damage management has been long perceived as the bane of wildlife managers, thus largely ignored. But in reality, this emerging discipline may offer managers a unique opportunity to increase stakeholder support of professional management (Berryman 1992).

The terminology "wildlife damage management" has traditionally been applied to economic losses caused by wildlife to agricultural crops and livestock. More recently, it has been applied to all situations that involve any and all negative interactions or conflicts between humans and wildlife in both rural and urban environments. These conflicts and/or damages can be either real or perceived, economic or aesthetic, social or political.

The Increasing Magnitude of Human/Wildlife Conflicts

Many North American wildlife populations are increasing. This, in conjunction with an increasing human population, has created the potential for more negative interactions to occur between humans and wildlife. Although many rural, suburban and urban residents enjoy seeing wildlife, negative experiences associated with locally overabundant wildlife populations or nuisance wildlife are increasing public concerns over these species (Connelly et al. 1987, Conover 1987, Decker and Gavin 1987, Conover et al. 1995, Conover 1997a, 1998, Messmer et al. 1997, Messmer et al. 1999). For example, white-tailed deer (*Odocoileus virginianus*) were once considered the "poster child" for professional wildlife management following their successful restoration in the Eastern United States. Now, despite the positive values that people still associated with this species, the number and intensity of the conflicts between deer and people caused Warren (1997: 213) to proclaim that management of overabundant deer to be "one of the greatest challenges facing wildlife management professionals during the next millennium."

The scope of negative interactions between humans and wildlife are much broader than just those involving white-tailed deer. More than 60 percent of urban and suburban households and 89 percent of the agricultural producers in the U.S. annually experience problems with some type of wildlife (Conover 1997a, Messmer et al. 1999). Urban households reported a mean annual loss of $63 per household because of wildlife damage. When extrapolated to all metropolitan households the loss exceeds $3.8 billion annually (Conover 1997a). This is nearly double the estimated losses reported by U.S. agricultural producers

(Conover 1998). Urban residents also reported spending more than 260 million hours and an additional $1.9 billion trying to solve or prevent these problems (Conover 1997a).

Additional human/wildlife conflicts include human illness and fatalities resulting from wildlife-related diseases, wildlife bites, attacks, deer/automobile collisions, and bird/aircraft strikes. Research suggests that in the U.S. approximately 35,000 people are injured or become ill, and 415 people die because of wildlife-related incidents each year (Conover et al.1995). The total impact of wildlife-related damage incidents exceeds $8 billion annually. Many resource managers still may view wildlife damage as an agricultural problem; however, these data clearly indicates that this issue reaches across demographic boundaries to affect a broad spectrum of stakeholders.

Although human/wildlife conflicts and the associated damage caused by wildlife are increasing, and more urban households are experiencing problems, many (69 percent) indicated that they try to actively manage for wildlife (Conover 1997a). Urban residents annually spent an average of $60 and 22 hours trying to enhance neighborhood wildlife populations. This amounts to $3.6 billion and 1.3 billion hours when extrapolated to the nation's 60 million households in the 100 largest metropolitan areas (Conover 1997a). Additionally, private landowners also are beginning to realize the substantial economic and social benefits associated with wildlife-related recreation (Messmer and Dixon 1997, Messmer et al. 1998). For example, in 1984, white-tailed deer provided $19.7 billion in benefits: $2.4 billion for hunter expenditures, $236 million value as meat, $4.3 billion for hunting recreation, and $12.8 billion for non-hunting recreation (Langenau et al. 1984, Conover 1997b). Much of this wildlife-related recreation is associated with privately owned lands. In the U.S., 2.1 million farmers and ranchers control more than 60 percent of the land base. As such, public wildlife inhabits and is dependent upon the habitat resources found on private land.

New Skills Needed To Better Manage Human/Wildlife Conflicts

To determine what skills will be needed by future professionals to better manage increasing human/wildlife conflicts, we surveyed administrators of state fish and wildlife agencies and the state directors of U.S. Department of Agriculture (USDA) Wildlife Services. This survey was conducted following guidelines developed by Dillman (1978). Specifically, we were interested in determining what agency administrators perceived as being the greatest threats to contemporary management and what approaches they felt would offer the most effective solutions.

Needs Assessment Results

We received completed surveys from more than 90 percent (N =73) of the agencies surveyed. More than 98 percent of the respondents expressed concern that increasing public opposition to wildlife management would affect how their agencies operate. Sixty-five percent indicated that public opposition to wildlife management practices is increasing in their states. Specific practices perceived by administrators as being at the greatest risk of being questioned by public stakeholders included trapping (reported by 97 percent of the respondents), wildlife damage management (96 percent), hunting (82 percent), habitat management (80 percent), endangered species management (75 percent), wetland management (72 percent), native species management (68 percent), and lands and refuge management (65 percent). Most respondents (57 percent) reported that increased interpersonal communication and development of new stakeholder partnerships (54 percent) were more effective at reducing opposition to wildlife management than any other technique.

More than 90 percent of the respondents stressed the need for increased communication with all public stakeholders. However, most administrators admitted that their agencies were not as effective as they needed to be in communicating with many groups. Audiences that were in need of the most attention included members of animal welfare/rights groups, urban residents, ranchers and farmers, young people, and nonconsumptive wildlife users. Given this strong expressed interest in communicating with stakeholders, it is ironic that agency funding forcommunication continues to lag (Case 1989).

Cooperation Needed to Create Formal Education Partnerships

We believe that academia and the professional natural resource community must cooperate to develop the formal education programs needed to better prepare young professionals to fulfill agency and societal needs. For this cooperation to occur, we believe three conditions must be present: (1) professors employed by natural resource schools must be responsive to change, willing to adapt and aptly rewarded for doing so, (2) university administrators must have the flexibility to reallocate internal resources to address emerging needs, and (3) the professional natural resource community must be willing to support academia, both politically and financially. Unfortunately, these conditions are seldom present in their entirety.

Natural resource schools periodically review and revise their educational curricula. Unfortunately, many of these reviews do not solicit input from alumni or contemporary employers. Arnold (1976) pointed out some inherent dangers associated with revising natural resource education curricula without stakeholder input. He stated, "There are too many inadequately prepared professors in too many schools training too many students to preform tasks that no longer exist. In other words, today's academic approach to natural resource management lacks force and substance related to current problems." Although we agree with him to some extent, we believe that the inadequacies he referred to are more symptomatic of societal megatrends rather than accurate reflections individual professors' level of academic competence.

Megatrends Affecting Natural Resource Education Programs

We can identify three factors that have been working in concert to create situations described by Arnold (1976). These factor include: (1) inherent differences between universities and natural resource agencies in their modes of operation; (2) increased stakeholder concern about the environment and an academic rush to capitalize on this interest; and (3) changing demographics of both students and natural resource professors.

The operational emphasis of natural resource agencies and universities differ because each has inherently different missions. Traditionally, resource managers have focused their efforts on trying to solve the daily biological, economic and engineering problems of resource utilization (Arnold 1976). Because of their training, research interests and institutional demands for tenure and promotion, university professors have largely focused their efforts on increasing the scientific knowledge base. Their efforts, in addition to allowing them to succeed in academia, also have resulted in new technologies that benefitted resource managers by increasing the number of tools which can be applied to solve problems. Thus, university education and educators for the most part have kept pace with the advancing technology and scientific discoveries (Arnold 1976). However, at times increased institutional emphasis on purely academic pursuits has increased the disconnection between the basic academic research and the applied needs of contemporary resource managers.

From both individual professors and institutional perspectives, the ability to adapt rapidly to changing trends may be somewhat limited because of one basic and important tenet: protection of academic freedom. To protect academic freedom and encourage professors to take risks, the university system has developed and facilitated a process of promotion and tenure to reward faculty. Under certain circumstances this system also may create inertia and serve to perpetuate stakeholder perceptions that universities are elitist organizations.

Lastly, there is growing consensus among natural resource educators that contemporary students entering university degree programs have less wildlife knowledge than their predecessors (Ledford 1996). Many students coming from urban backgrounds have fewer practical experiences than those with rural backgrounds. Additionally, professors who may be interested, qualified and willing to provide practical outdoor management experiences frequently find themselves faced with other demands (i.e., securing research funding, conducting research and publishing in peer-reviewed journals) which limit the amount of time they can devote to outdoor labs and field trips. The irony of this situation is that today, more than ever, wildlife students who benefit the most from more field experiences are now less likely to receive them.

Natural resource schools have demonstrated an ability to adapt to meet emerging needs and issues (Arnold 1976, Rollet and Block 1982, Slack et al. 1982, Schmidt et al. 1993). They have diversified their curricula to include planning, recreation, conservation biology, wildlife damage management, remote sensing, and human dimensions. However, this evolution was probably as much of an effort on the part of universities to increase enrollments and attract better students than adapt to agency needs. Even schools with little background in natural resource management now offer education programs in this area (Arnold 1976).

Universities can address these problems and dispel stakeholder misconceptions by opening their doors to increased public scrutiny and accountability. We believe that if university administrators and educators are truly committed to preparing young professionals to meet agency and society needs, they must be willing to go beyond the walls of academia to engage all their stakeholders in meaningful discussions and periodic reviews of academic programs. These reviews will create and reinforce a sense of ownership in university programs by the natural resource community. To be truly meaningful, these reviews also must include a critical analysis of not only the subject matter taught but teaching methodology, administrative structure, and professorial qualifications.

The importance of such partnerships in natural resource management was addressed in special symposia at the Fifty-eighth, Fifty-ninth, and Sixty-second North American Wildlife and Natural Resource Conferences (Nielson 1993, Nelson, 1994, 1997). Natural resource partnerships also have become the mainstay of international conservation efforts such as the North American Waterfowl Management Plan and Partners-in-Flight. The development of new educational partnerships to better prepare future professionals to meet changing agency and societal needs should receive the same.

An Educational Partnership Created Better Manage Human/Wildlife Conflicts

As previously discussed, overabundant wildlife can cause myriad problems (e.g., deer/vehicle collisions, disease, reduced agricultural production, residential damage). Traditional academic programs in fisheries and wildlife management have not adequately prepared biologists and managers to deal with many of these problems (Timm 1982, Schmidt et al. 1992). There is an increased need for research, education, and extension programs to identify, design, communicate, and evaluate alternative strategies that can be implemented to better manage human/wildlife conflicts. The development of new strategies and approaches by wildlife management agencies to address landowner, homeowner and other stakeholder concerns regarding wildlife damage also can enhance agency communication efforts (Hewitt and Messmer 1997).

Jack H. Berryman Institute for Wildlife Damage Management

To address these concerns, the Jack H. Berryman Institute for Wildlife Damage Management (BI) was created in 1992 in the College of Natural Resources (CNR) at Utah State University (Conover et al. 1991, Schmidt et al. 1992). The Institute was named after Jack H. Berryman, an Aldo Leopold Award recipient, former Director of U.S. Fish and Wildlife, Wildlife Services, and past Executive Director of the International Association of Fish and Wildlife Agencies (IAFWA). The BI is largely supported by grants received from USDA Wildlife Services and other federal, state and private agencies and organizations (Conover et al. 1991, Schmidt et al. 1992). The BI operates the only academic degree program in the world that specializes in training wildlife damage management professionals. The BI conducts international, national, and regional research, education, and extension programs to address wildlife damage management concerns (Conover et al. 1991, Schmidt et al. 1992). To date, the BI has graduated and placed over 60 professionals trained in the management of human/wildlife conflicts in positions with several public and private natural resource management agencies and organizations. The bulk of BI graduates are employed as biologists and scientists with USDA Wildlife Services. The BI maintains liaisons with public and private wildlife conservation and management agencies and organizations, wildlife researchers and wildlife damage management specialists employed by land grant universities, federal and state agencies, and by the private sector.

In part, due to the BI's continuing education, research and extension programs that are conducted in cooperation with public and private partners, professional wildlife damage management now has emerged as a new discipline of wildlife science. This new discipline seeks to resolve human/wildlife conflicts by enhancing the positive values associated with wildlife and reducing the negative interactions.

Quinney Professorship for Wildlife Conflict Management

In 1998, through the generosity of the S.J. and Jessie Quinney Foundation, CNR was able to establish the first academic professorship to address human/

wildlife conflicts. The goals of the Quinney Professorship for Wildlife Conflict Management are similar to the BIS, with one important addition; increased emphasis has been placed on creating new partnership to better manage human/wildlife conflicts.

Natural resource management agencies are charged with managing public resources for the benefit of society. As human populations grow, the demands placed on natural resources increase and the complexity of the problems become magnified. At the same time, the budgets of many of the natural resource agencies charged with managing the resource are declining. Declining budgets translate into smaller work forces. Thus, contemporary natural resource management professionals are frequently called on to do more with less. One solution to this dilemma has been the increased use of public and private partnerships that pool limited resources to address complex problems (Nelson 1994, 1997).

Unfortunately, few classes taught at academic institutions adequately prepare future managers for the challenge of forming and managing these partnerships (Nelson 1997). Much of what it takes to be successful at establishing and managing these natural resource partnerships comes from on-the-job training (Nelson 1994). To provide this training in a university setting, we developed a course patterned after the Ecosystem Stewardship and Partnering Workshop developed by the U.S. Fish and Wildlife Service Management Assistance Team (Nelson 1997).

A Natural Resource Partnership Course for Young Professionals

The goal of the course was to give students practical experience in developing, implementing, and evaluating community-based conservation partnerships. The course was arranged to follow a logical sequence that could be followed by a wildlife manager to develop an actual partnership. The topics discussed included:

1. Creating natural resource management partnerships: The elements of successful partnerships and plans;
2. Identifying potential partners based on aspects of the natural resource management problem: Defining the problem and finding potential partners;
3. Developing partnership implementation plans: Elements of a plan;
4. Developing partnership/project budgets;
5. Developing and implementing partnership communication programs;
6. Preparing grant proposals to support partnerships;
7. Case Study: Deseret Land and Livestock;
8. Case Study: Monroe Mountain;
9. Case Study: Bear River Migratory Bird Refuge;
10. Conducting/facilitating better partnership and public meetings; and
11. Managing natural resource conflicts.

Course organization. The course consists of a weekly lecture/discussion periods and laboratory sections arranged to encompass public meetings and unique partnership opportunities. Class discussions dissected assigned readings and related materials. Guest lectures featured public and private natural resource managers who had formed partnerships to better manage difficult resource problems. In addition to the lectures, weekend and evening field trips are conducted to visit the sites discussed by the guest lectures.
Course deliverables. In addition to regular participation in class and on the field trips, students arerequired to identify a natural resource management issue and develop a hypothetical or real partnership that could be implemented to manage a specific problem. Realizing that no two problems are the same, course participants are given the luxury of developing an individualized partnership. However, the basic elements of successful partnerships as discussed in class are required to be incorporated into the plan. Course participants are required to make an oral presentation defending of their partnership in class and hand in a copy of their final plan.
Course feedback. The partnership course received one of the highest evaluations for courses taught in CNR during the spring 1999 semester. Students noted in their evaluations that the course provided realistic training and experiences which they could immediately use. Probably the best evaluation of the course was that four students received funding and support for the partnerships proposals they developed in the class. One of the partnerships, designed to monitor breeding bird diversity on private ranches in Utah, has secured funding to support a Ph.D project for the student author.

Conclusions

As we move into the next millennium, it is clear that academia and the natural resource community must become more responsive to the needs of society. Our ability to recognize, evaluate and fulfill the needs of stakeholder groups will be key to continued public support for and the success of professional resource management. Although management agencies and academia have made significant strides in addressing contemporary resource challenges, it is readily apparent neither can succeed without the other. Both academia and agency must be willing to take risks and work to eliminate the institutional inertia that precludes effective partnering. Management agencies must be willing to provide the resources necessary for academic programs that focus on addressing their needs. Concomitantly, academicians and natural resource school administrators must more fully embrace agency needs and demonstrate an increased willingness to adapt educational program to meet them.

The Jack H. Berryman Institute for Wildlife Damage Management and the Quinney Professorship for Wildlife Conflict Management are excellent examples of the types of partnerships that are needed to turn natural resource challenges into conservation opportunities. For these partnerships to occur, three things had to happen. First, the primary management agency (USDA Wildlife Services) had to recognize that there was a need to specifically train young wildlife damage management professionals. Second, the agency had to be willing to commit the resources necessary to support the development and implementation of the educational program. Third, the university had to be provide institutional and administrative support. The College of Natural Resources at Utah State University aggressively pursued this arrangement. Amend (1993) stated that new approaches have to be implemented to improve the effectiveness of wildlife agencies and academia. We believe the creation of issue-based educational partnerships such as BI will become increasingly important in assisting the natural resource community in preparing new professionals to address agency and societal needs.

Acknowledgments

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Registered Attendance

Alabama
David C. Hayden

Alaska
Doug Alcorn, Dave Allen, Gene Augustine, Carrie Barta, James Bartelme, Rick D. Cables, Ellen Campbell, Erin Cooper, Tina Cunning, Christopher Estes, Jacqui Frair, Robert Gill, Herman Griese, Gary Larsen, Robert R. Leedy, Joni Leet, James B. Leet, Thomas J. Liebscher, John F. Payne, Wayne Regelin, Steve Reidsma, Matthew H. Robus, Ken Taylor, Kate Wedemeyer

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Donald R. Fairley, Mike Gibson, Jim Goodhart, Sabrina Kirkpatrick, Joseph D. Long, Donald F. McKenzie, Gregg Patterson, Bill Robinson, Steve N. Wilson, Scott Yaich

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Randy M. Miyashiro

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West Virginia
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David Beckmann, Harold W. Benson, Jon R. Bergquist, Diane L. Brookbank, Jim Christenson, Marilyn A. Davis, Dan Dessecker, Cheri Ford, Brent Friedl, Tom Hauge, Steve Kessler, James Kurtz, Missy Lien, Ricky Lien, Diane Lueck,

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Wyoming

Kaush Arha, John Baughman, Lynda G. Cook, Jean Cove, Robert H. Hanson, Arlene P. Hanson, Wayne Hubert, Paula Karres, Larry L. Kruckenberg, Jay Lawson, Robert Model, Larry Roberts, Tom Rowe, Steve Sharon, Leland Speakes, Jr., Scott Talbott, Tom Thorne, Bill Wichers, Matt Wolfe

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Kenneth F. Abraham, Michael G. Anderson, Len Baydack, Rick Baydack, Mark S. Boyce, Danielle Bridgett, Brett Calverley, Bob Carles, Bob Carmichael, Douglas A. Chekay, Bridgitte Collins, Lorne Colpitts, Kenneth W. Cox, George Finney, Brian C. Gillespie, Mark Gloutney, Brian T. Gray, Trish Hayes, Deanna Knudson, Yvan Lafleur, Jim Leafloor, Dan Mansell, Gerald McKeating, Bob McLean, Reg Melanson, Jack Morris, Lena Nudds, Tom Nudds, Michael O'Brien, Richard Pratt, Barbara Robinson, Ken Ross, Raymond Sarrazin, Jean-Pierre Savard, Jonathan Scarth, Gary R. Stewart, Darryl Thachuk, Evan Thomas, Steve Wendt, Marieke Wijtkamp, Arthur Willett, John Williamson

Japan

Mitsugu Sugiyama

Puerto Rico

Paula Claudio, Craig Lilyestrom, José B. Montalvo

Russia

Evgeny Kuznetson, Sergei Minkov, Vladimir Safonov

Accepting the Wildlife Management Institute's 2000 Presidents' Award, on behalf of the Texas Master Naturalist Program, of the Texas Agricultural Extension Service and the Texas Parks and Wildlife Department, is Michelle Haggerty, Program Coordinator, flanked by Program creators Judit Gowen and Rufus Stephens. WMI president Rollin D. Sparrowe (left) makes the presentation.

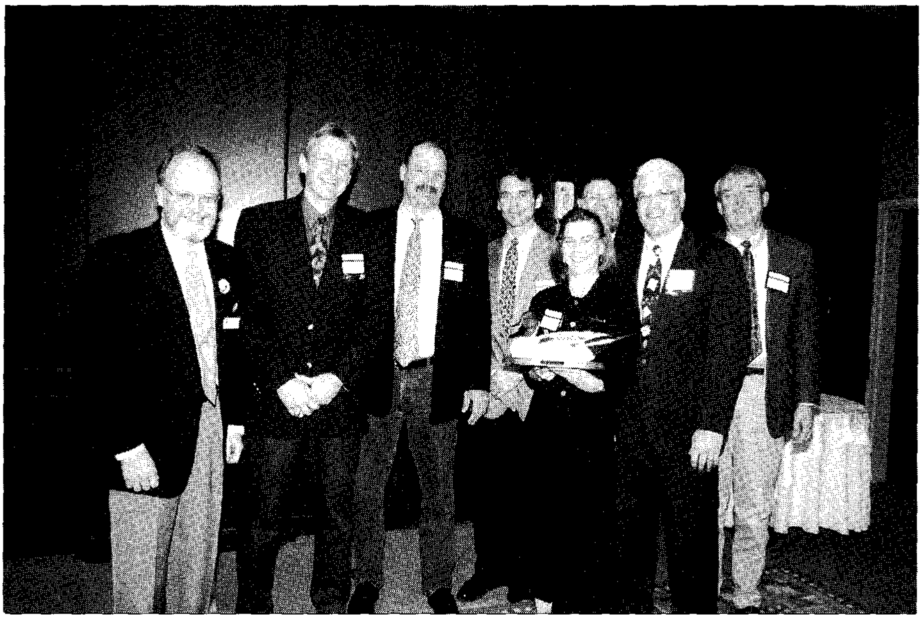
Texas Master Naturalist Program Receives WMI's 2000 Presidents' Award

The Texas Master Naturalist Program of the Texas Agriculture Extension Service and the Texas Parks and Wildlife Department received the Wildlife Management Institute's Presidents' Award during the 65th North American Wildlife and Natural Resources Conference. The award commemorates the mission-oriented drive and foresight of the Institute's past presidents and specifically recognizes an agency's department, division or office for particular ingenuity and accomplishment, advancing the scientific management of natural resources in North America.

The Texas Master Natural Program develops and trains local corps of volunteers to provide education, outreach and service dedicated to beneficial management of natural resources and natural area within their communities.

Since its conception two years ago, the Program has had 472 Texas Master Naturalist volunteers, with about 3,000 hours of training, dedicate more than 22,600 of service to community natural resource projects. The Program has directly involved more than 25,000 citizens in its projects. Together, Program volunteers and private citizens have helped to improve more than 4,000 acres of prairie, woodland and riparian habitat through Program projects and network.

Accepting the award were the Program's creators, Rufus Stephens and Judit Gowen, as well as Michelle Haggerty, Program coordinator, Bob Brown from Texas A&M, on behalf of the Texas Agriculture Extension Service, and John Herron of the Texas Parks and Wildlife Department.



Wildlife Management Institute president Rollin D. Sparrowe (left) presents WMI's 2000 Touchstone Award to members of the Buffers For Wildlife Group, including (l-r) Hank Henry, Wendell Gilgert, Bill Hohman, Kathy Staley, Virgil Kopf, Steve Hall and Ed Hackett.

Buffers For Wildlife Group Receives WMI's 2000 Touchstone Award

At a special ceremony at the 65th North American Wildlife and Natural Resources Conference, the Buffers for Wildlife Group received the Wildlife Management Institute's Touchstone Award. This award recognizes an investment of a particular innovation and accomplishment in advancing professional natural resource management in North America.

The Buffers for Wildlife Group was selected for its ingenuity and tenacity in cooperatively developing and implementing communication vehicles to assist field-level professionals deliver farmland conservation plans and programs to landowners, resulting in wildlife enhancement across the United States. It encourages representatives from the Natural Resources Conservation Service (NRCS) and state fish and wildlife agencies to meet to construct state-specific "job sheets." Cooperation in designing these "job sheets" not only helps NRCS personnel to implement wildlife-friendly conservation plans, but it encourages all parties to reach a consensus on how reach a common goal. Many believe that the communications facilitated and partnerships created by the Group will directly contribute to increasing the acreage contribution to the 2002 miles buffer goal of the National Buffer Initiative.

The Buffers for Wildlife Group includes Hank Henry, Charlie Rewa, Ed Hackett, Kathy Staley, Wendell Gilgert and Bill Hohman, from NRCS, as well as Virgil Kopf, Virginia Department of Game and Inland Fisheries; Edith Thompson, Maryland Department of Natural Resources' Wildlife and Heritage Division; Steve Hall, Texas Parks and Wildlife Department; Allan Clark, Utah Division of Wildlife Resources; Dick Warner, University of Illinois Extension; and Pat Kuck, South Dakota Department of Environment and Natural Resources.

Bill Stevens (right), of Federal Cartridge Company, Anoka, Minnesota, accepts Wildlife Management Institute's 2000 Distinguished Service Award from WMI president Rollin D. Sparrowe.

Bill Stevens Receives WMI's Distinguished Service Award

At the 65th North American Wildlife and Natural Resources Conference in Rosemont, Illinois, the Wildlife Management Institute (WMI) bestowed its Distinguished Service Award on Mr. William Stevens, Manager of Conservation and Legislation for Federal Cartridge Company. The award celebrates individuals whose careers have made a profound, yet largely unheralded contribution to the science and profession of natural resource conservation.

Bill Stevens has been Federal Cartridge Company's primary liaison with the natural resources community for 35 years. He has directed Federal's generous support to hundreds of start-up conservation projects. Bill's insight and vision on these sorts of projects, as well as the financial or other material support, have helped ensure their success. Even when Federal was unable to provide direct support, Bill personally endorsed various projects, which often gave them the leverage they needed to gain additional support elsewhere.

Support authorized by Bill has made huge contributions to the well-being of mourning doves, deer, wild turkey, waterfowl, quail, pheasants, elk and other species. Because of his support, the U.S. Olympic Shooting Team, 4-H Shooting Sports, hunter education programs, The National Shooting Range Symposia and Becoming An Outdoors-Woman all are alive and prospering.

In presenting the award, Dr. Rollin Sparrowe, president of WMI, applauded Bill Stevens' courageous leadership during the early days of steel shot investigation, regulation development and implementation. Dr. Sparrowe stated, "His gentle insistence on science and common sense were vital to getting support—albeit initially reluctant—from industry and the hunting community, both of which ultimately benefitted. More so, the lead contamination jeopardy to waterfowl was greatly diminished."

Bill Stevens is the first-ever recipient of the Wildlife Management Institute's Distinguished Service Award.