Endangered Species UPDATE

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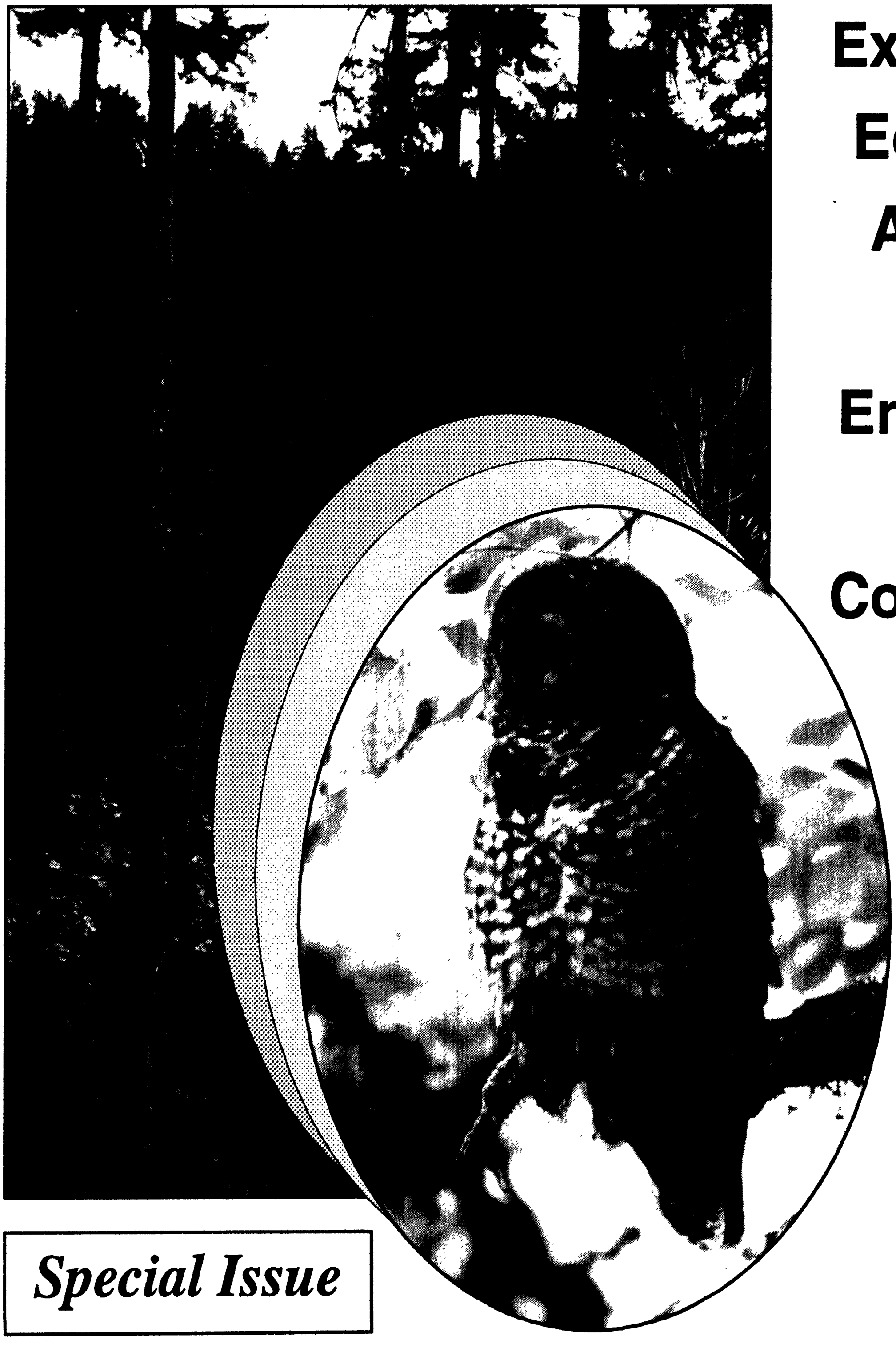

Exploring an Ecosystem Approach to Endangered Species Conservation

Special Issue

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Exploring an Ecosystem Approach to Endangered Species Conservation

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Introductory Note

Science and Management

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For Skeptics Only

by

Judy Tasse

When the associate editor of the *Endangered Species UPDATE* suggested this topic for our Special Issue, I winced. As a student of conservation biology, having been trained in ecology with a population biology emphasis, I was skeptical of the ecosystem approach. But as we made our initial inquiries, it became clear that more and more people working in the conservation arena were taking notice of the idea of an ecosystem approach—they were thinking about it, talking about it, implementing it. This was an issue well worth exploring.

On the whole, the authors in this Special Issue take an unabashed stance favoring an ecosystem approach to endangered species conservation. Yet, up until now, the paradigm for conservation has been species-oriented. The intent of this Special Issue is to bring together in one volume, the oft unheard voice of the ecosystem approach subscribed to by the varying disciplines affecting endangered species conservation. Thus, while not a denial of the usefulness of a species approach, the authors argue that not only is a species approach alone insufficient, but in certain instances, inappropriate.

Drawing Lines are Difficult

The Special Issue tackles ecosystem approach questions within three sections: Science and Management, Policy, and Education; although the lines are sometimes murkily drawn. For example, in the Science and Management section, both LaRoe (pages 3-6) and Quigley & McDonald (pages 30-33) refer to the jurisdictional difficulties in ecosystem management. In the Policy section, both Meslow (pages 34-38) and Pashley & Creasman (pages 42-47) flesh out their articles with biological data and resource management criteria. Finally, in the Education section, Schmidt (pages 58-60) notes that the value of teaching conservation from an ecosystem perspective can be more than heuristic; it may lead to communication to policymakers and resource managers themselves.

Fiedler et al. (pages 7-12) provide a context for conservation scientists and managers through a concise discussion of the recent paradigm shift in ecology, and its effect on species conservation. They say rather than managing species, we should manage processes. Fiedler et al. call on conservationists to utilize ecological theory to advance the progress of species protection. Among many questions, they pose and answer the difficult question: How do you manage process?

Answering Critics' Questions

Critics of ecosystem management may fear that such a strategy will inadvertently cause the loss of the very species we are trying to protect, due to such a large, overview approach. However, LaRoe clarifies an essential piece of ecosystem management, which should alleviate the fears of these species-oriented conservationists. The point is one of defining goals. If the management regime explicitly charters, as one of its goals, the protection of particular species, then an ecosystem approach would not undermine this.

One set of recurring questions is asked by those not versed in the methods of an ecosystem approach: Is an ecosystem definable by scientific terms? (Even some of the authors in this issue use widely differing scales in their discussion of "ecosystem", i.e., from local land forms to the Great Lakes.) Can a definition of ecosystem be implemented from the management stance?

Barnes (pages 13-19) gives the definitive answers by detailing the landscape ecosystem approach, with examples of how identification and mapping of landscapes are done in the field. Barnes' methodology is echoed by Albert (pages 20-25) who demonstrates how this system works on the ground, in Michigan, for species inventory and management. Rounding out this discussion, Taylor (pages 26-29) points out that ecosystem management can mean many different things to many different people. How we define an ecosystem approach will be key to its success as a management tool.

An ecosystem approach focuses on landscape-level processes (natural and human) that support or affect the area, such as this wetland, as a means of conserving the species within it. (Wetland in Lower Iron River, a tributary to Lake Superior. Photo by Joan Elias.)

When Ecosystem Management Means Endangered Species Protection

Two endangered species are highlighted here by several authors—Kirtland's warbler and the northern spotted owl. For both species, protection has evolved towards an ecosystem management approach. However, one interesting contrast is that in the case of the warbler, this was intentional (see Taylor), while in the case of the owl it was not (see Meslow).

Though controversial, one can make a strong argument to exert a concerted effort for a particular species when the extinction of that species is imminent (egs., the California condor and the black-footed ferret). Yet, that scenario is separate from one in which a proactive mode of conservation is applied.

It is in the proactive mode that an ecosystem approach can excel. Serfis (pages 39-41) explains that this approach is now being embraced by the Environmental Protection Agency, a federal agency heretofore addressing species preservation concerns only indirectly. As a result of the holistic emphasis, species in sensitive areas, such as wetlands, will benefit.

With the myriad of agencies, and public and private interests in endangered species protection, a method that is based on intergroup cooperation may shed light on how we can proceed effectively. This method is discussed in detail by MacKenzie (pages 48-51). When the decision has been made to use an ecosystem approach, MacKenzie's article gives insights to the potential obstacles and resolutions revolving around interagency cooperation in an expansive ecosystem like the Great Lakes. Pashley & Creasman highlight the importance of public-private organizational partnerships among a variety of parties who have an interest in the species or ecosystem in question.

Thinking "Ecosystems" is Learned

Several of the authors remind us of the extraordinary expense in species-by-species approaches, and offer this as another reason to move towards ecosystem conservation. However, in today's reality, a fair rebuttal to this criticism is that species conservation is done because *that* is where the money is; *that* is where people are willing to donate. This truism points out the inadequacy in our education system, which teaches the value of only individual species (and only certain species, at that), rather than the inherent value of the system in which these species dwell. Schmidt cogently argues that ecosystem-oriented education is the way to turn this thinking around, bringing more connectivity to an individual and the ecosphere.

Formal education programs are only one part of the equation in raising awareness. To enable people the ability to really get the "feel" of a link between the world and their urban or suburban lives, a concrete, tangible action is needed. Such is the reward of zoo-goers who partake in the Conservation Parking Meters (in Gershenz and Saul, pages 61-62).

Taking this idea of experiential reward to the maximum, Robinson (pages 52-57) outlines his vision of holism and integration represented through BioParks. What better way to enlighten the public about the interconnectedness of the ecosystem, than by "walking" within it.

The articles here represent just a sampling of those people engaged in ecosystem work. Even still, bound in one volume, it may appear overbearing to conservationists who have dedicated their work to single-species approaches. Yet, these authors are merely offering a different way to approach a problem which does not seem to be resolving. In a time when extinctions far outnumber recoveries, we ought to welcome alternative avenues. I hope that this Special Issue acts as a springboard for future dialogue within the conservation community.

Judy Tasse is the Editor of the *Endangered Species UPDATE*. She is a Ph.D. student in the School of Natural Resources and Environment at the University of Michigan, studying mechanisms for wildlife reintroductions and movements of individuals in small release populations.

Endangered Species
UPDATE

A forum for information exchange on endangered species issues

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Cover: A small piece of the Pacific Northwest old-growth forest ecosystem (photo by E. Charles Meslow, Oregon Cooperative Wildlife Research Unit) and one of its well-known inhabitants, the northern spotted owl, *Strix occidentalis caurina* (photo supplied by the Oregon Cooperative Wildlife Research Unit).

Implementation of an Ecosystem Approach to Endangered Species Conservation

by

Edward T. LaRoe

The world, and our nation, face a major environmental crisis: the increasing loss of biological diversity. The Endangered Species Act (ESA) is a critical component of United States conservation law and the strongest single authority directed toward the protection of biological diversity. Despite its importance and its strength, however, many ideas have been suggested to improve its implementation. Perhaps the most common criticism is that the Act's implementation, like much of the traditional fish and wildlife profession, is focused on individual or single species.

Increasingly, wildlife scientists are recognizing that management oriented toward single species is only partially successful: while some species (e.g., deer and turkey) have shown at least temporary improvements, others, including the two groups of species receiving the greatest level of funding and support in the U.S. Fish and Wildlife Service—ducks and salmonids—have exhibited long-term population declines.

More recent evidence of similar reductions in many non-game species, such as many Neotropical migratory birds; many species of non-game fish; a variety of invertebrates, such as freshwater mussels; and many habitat types, e.g., wetlands, riparian forests, and tall grass prairies, suggest wide scale, systemic failure of ecosystems nationally. Over 1,200 taxa are listed as threatened or endangered under the ESA, and almost 4,000 species have been identified as candidates for listing. Respected biologists (e.g., Wilson 1992) suggest that 20% of all species on earth today may be lost due to extinction in the next 40 years, an event that would rival the greatest geological extinction episodes.

A New Paradigm

Clearly the resource management profession needs new tools to address this kind of threat. One alternative to the species-oriented approach is the management of ecosystems. Although promoted by Aldo Leopold over 50 years ago, ecosystem management is not yet widely practiced or accepted. Where the focus of resource managers has shifted beyond a single species, it is still too frequently limited to an artificially determined administrative unit such as a national forest, park, or refuge, rather than management units that are biologically meaningful. In addition to the argument that traditional species-oriented management is not working, three other reasons support the need for ecosystem management.

First, resource management problems today are increasing in complexity, space and time. The nature of the problems that confront our resources are larger in scope and in size than those of the past. Resource managers today face a long list of problems (see Box this page) that were not even addressed when most mid-level managers were in graduate school.

The nature of these problems requires new tools, new concepts and new ideas in the management of resources. Resource managers will increasingly have to rely on remote sensing techniques, systems models, computer tools such as geographic information systems, and population viability analyses to be able to cope with the variety and magnitude of today's problems. Most significant, however, is that solutions to these large, complex problems must fully encompass their size and scope to be effective. As a result, perhaps the single greatest change in resource management should be the shift to an integrated, holistic approach to the management of

Today's Resource Management Problems

- Loss of air quality and deterioration of airsheds
- Decreasing water quality and availability of water
- Acid rain, particularly in the northeast of the United States
- Increasing ultraviolet radiation at the earth's surface resulting from decreased stratospheric ozone
- Global climate change, which has the potential for widescale effects on precipitation patterns, storm frequency, and sea levels as well as simply warming
- Large-scale marine problems, including the increase in frequency and duration of red tides and massive mortality of several species of marine mammals in the North Atlantic Ocean
- The global decline of biological diversity, the capital upon which all life is based
- An increasing global human population that now places stresses on ecosystems at regional levels as well as on habitats and individual species

large ecosystems as opposed to single, individual species.

Second, ecosystem management offers a variety of benefits to resource managers. It would allow resource management to operate in the context of surrounding land uses. Too often, resource managers ignore the surrounding resource activities because they focus their efforts on a species or a small geographic area. Increasingly, however, we are finding that it is the surrounding or regional land uses that may have major impacts on the target resource. Thus, by expanding their horizons, managers can plan for the resource in the context of surrounding land uses.

The third, and perhaps the biggest benefit of ecosystem management, however, is that it offers improved cost effectiveness in management activities. The bulk of efforts and dollars spent today by resource managers are expended on relatively few species. Historically, these have been game species, such as waterfowl, salmon or bass, deer, and a few upland game birds. Even in the endangered species arena, however, activities focus on a few species (Figure 1). The Fish and Wildlife Service reports, for example, that in Fiscal Year 1990, of the 591 listed endangered or threatened species in the United States, only 10, or 1.7%, account for about half of the total amount of reported expenditures (Table 1); 58 species, 10% of the total, account for 90% of all reported expenditures. While we spend huge sums on a few species (for example, over $9M on the northern spotted owl in 1990), we spend little or nothing on the vast majority: 151 (25%) of the listed domestic species had reported expenditures of under $1,000, and 114 (19%) had no expenditures at all. With this level of effort, resource managers will never be able to significantly address more than a few species unless they can redirect their focus to ecosystems and the multiple species they contain.

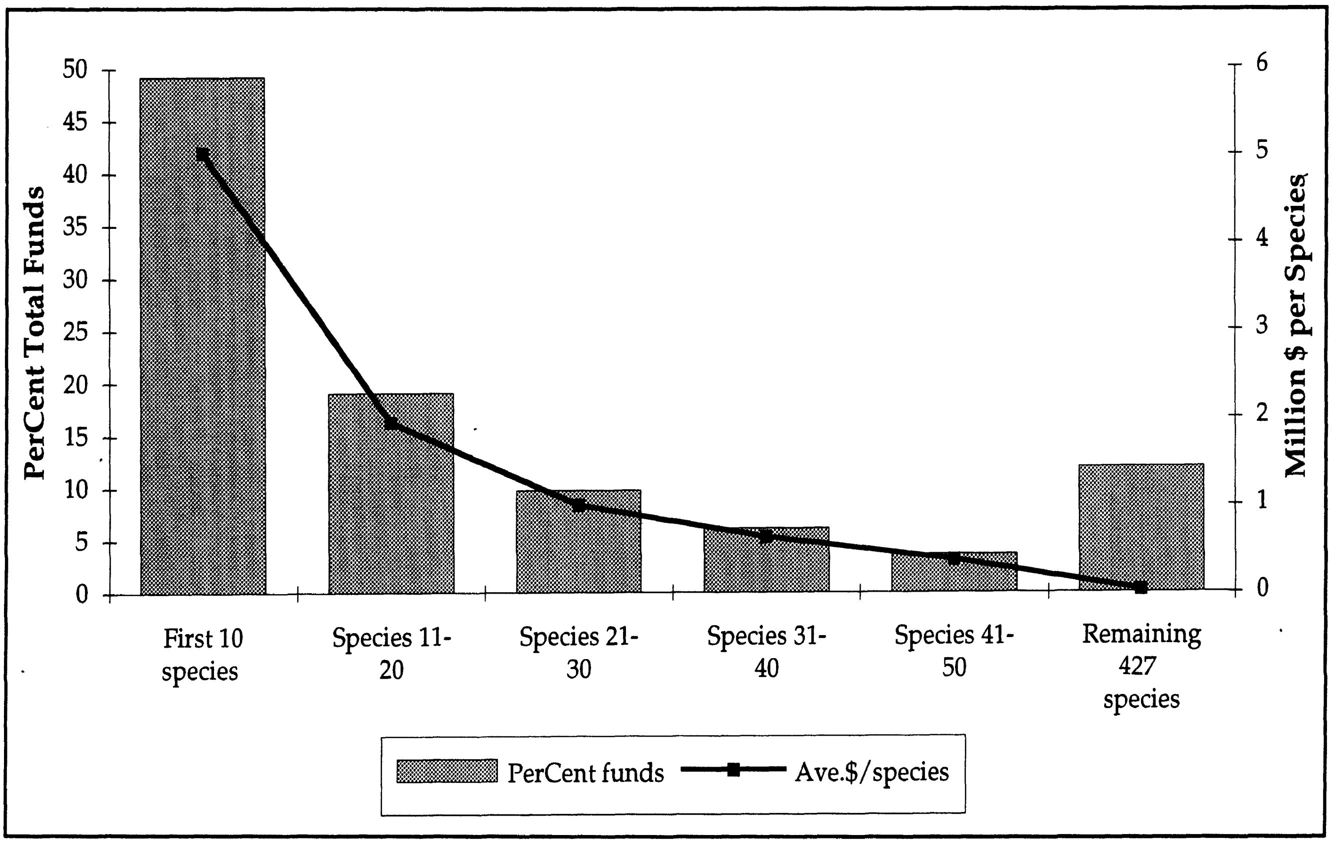

Figure 1. Distribution of funding for domestic endangered species, FY1990. Almost 50% of the total funding was spent on the top 10 species, which received an average of over $5 million in 1990. In contrast, the last 427 species received only about 12% of the funding, for an average of about $12,000 each. (Source: U.S. Fish and Wildlife Service, 1991.)

A Case for Holism: The Old Growth Forest

Scientists generally agree that the biggest single cause endangering species today is habitat loss. Where we have areas of rapid large-scale habitat change, such as in California and Florida, we have the greatest number of listed species. These problems can be more easily addressed by a generalized approach dealing with habitat or ecosystems, rather than the present effort addressing every species individually.

The folly of a single species approach may be best demonstrated by the recent efforts on behalf of the northern spotted owl (*Strix occidentalis caurina*) and, more recently, the marbled murrelet (*Brachyramphus marmoratus*). The federal government, several states and the private sector over a multiple year period, have invested tens of millions of dollars in the process of reviewing and listing the northern spotted owl as a threatened species under the Endangered Species Act. More recently, federal agencies completed a recovery plan, identifying critical habitat necessary for maintenance and recovery of the spotted owl.

During the discussions on the spotted owl it became clear that much of the issue related to the conservation of old-growth, Douglas-fir, northwest forest ecosystems. Many assumed that a plan meeting the needs of the spotted owl would also protect other species dependent upon old-growth forests.

Recently, however, the Fish and Wildlife Service began a review of the marbled murrelet, another old-growth dependent Pacific Northwest species that has just been listed as threatened under ESA. It quickly became apparent that the area set aside for the spotted owl would not meet the needs of protecting the marbled murrelet, because the marbled murrelet had one different habitat requirement than the owl: its optimal habitat is close to the ocean coast, because the murrelet, unlike the owl, feeds at sea.

Table 1. Distribution of Funds for Domestic Endangered Species, FY1990. (Source: U.S. Fish and Wildlife Service, 1991.)

Species	USFWS Funds ($x1000)	Other Funds ($x1000)	Total Funding ($x1000)
Northern Spotted owl	$853.8	$8833.4	$9687.2
Least Bell's vireo	135.0	9033.8	9168.8
Grizzly bear	679.2	5203.3	5882.5
Red-cockaded woodpecker	310.3	4883.7	5194.0
Florida panther	1040.1	3073.8	4113.9
Desert tortiose	460.9	3630.5	4091.4
Bald Eagle	620.0	2890.7	3510.7
Ocelot	2924.3	55.9	2980.2
Jaguarundi	2892.1	1.0	2893.1
American peregrine falcon	1047.0	1826.3	2873.3
Total, first 10 species	**$10,962.7**	**$39,432.4**	**$50,395.1**
All remaining 581 species	**$24,299.5**	**$27,649.1**	**$51,948.6**

Clearly, the issue should not be limited to how to protect the owl, but what habitat mix would optimally maintain those species that are dependent upon old-growth forest ecosystems. Having solved it once for the owl, resource managers are now faced with solving the "equation" a second time for the marbled murrelet and, most assuredly, later on for other species such as the pine marten (*Martes americana*). A more effective alternative is to look at the ecosystem in a holistic fashion.

Ecosystem management, then, is not only more cost effective, allowing managers to deal with multiple species simultaneously, but provides greater opportunities for long-term success. In the context of the ESA and resource management in general, an ecosystem perspective is necessary to attain our long-term resource management objectives.

Perceived Problems with an Ecosystem Approach

Given the clear benefits of management for ecosystems, why have resource decision-makers resisted the change to an ecosystem approach? Several factors have affected their reluctance.

First, an ecosystem approach expands the political jurisdictions and problems that managers must face. Generally, management at an ecosystem level would involve more political units, more landowners and greater potential for conflict. This alone makes planning and management more difficult.

Secondly, an ecosystem is a difficult ecological concept, and attempting to define any ecosystem on the ground involves some arbitrary judgement. Ecosystems seldom have sharp, distinct boundaries; they usually grade gradually from one to the next. Placing a line on the ground—or a map—often involves substantial interpretation and judgement. Moreover, the concept of an ecosystem can be applied at different scales. With substantial justification, one can define a small pond, a large watershed, or the entire planet as an ecosystem. Biologists tend to hide behind complex definitions to cover the subjective or arbitrary nature of such decisions. These definitions are difficult for the lay public to understand, and the resulting ambivalence and uncertainty can create hostility and opposition. Managers could more easily acknowledge up front that ecological units go through gradual transitions from one unit to another, and that any human-drawn boundary involves some aspect of arbitrariness. This is not to say that it is not based on sound scientific principles, or that it is scientifically unsound. It does suggest that if different biologists approach the problem differently at different times or for different objectives, they might come up with different boundaries for an ecosystem. If they work together, however, the same biologists can usually agree on a common unit or area to define as an ecosystem.

The third problem is that an ecosystem approach increases the biological complexity the managers must face.

Managers have a hard enough problem predicting results of management decisions and actions on one or two species. Examples abound where a management effort directed toward one species has inadvertently affected other species in unanticipated ways; for example, programs to reduce first wolf and then coyote populations in the Northern Great Plains resulted in an increased population of the red fox. Red fox, however, are greater predators on waterfowl than either wolves or coyotes, and this increase in predatory pressure has been suggested as one of the reasons for the decline in waterfowl today. Given the difficulty of managing individual species, many managers resist the more complex effort needed to manage an ecological system.

The last major problem with an ecosystem approach is that it may initially be more expensive than a resource activity directed toward a single species. The size and scale as well as the complexity of the issue often increase the effort and funds needed to address ecosystem problems. In addition, more sophisticated tools, particularly computer tools, will often be needed. As indicated, however, the large initial expenditures will usually be offset by long-term cost savings—planning for the system as a whole will cost far less than the sum of plans for all individual components—and by the fact that an issue will have to be visited only once rather than repeatedly for a variety of different species.

Cataloguing Elements of Biodiversity

Ecosystem management has no set physical boundaries. It manages within the dynamic arrangement of biophysical elements: species, communities, and landscapes. After determining the boundaries of the unit to be managed, the second step is to identify the distribution of individual plant and animal species within the management unit. The Fish and Wildlife Service's Gap Analysis Project (Scott et al. 1987) provides one approach to partially answer that need.

The Gap Analysis Project uses modern computerized geographic information systems to map the distribution of vegetation types. Using the computer, scientists then project the distribution of terrestrial vertebrate species, using sophisticated models and historical records and data such as the Natural Heritage database, to check this projection. Gap Analysis data also include information on the distribution of endangered, threatened or candidate species, including plants, vertebrates and invertebrates. Information from the Gap Analysis database can identify hotspots of biological diversity or areas that contain several endangered or candidate species with overlapping ranges. This kind of information can help focus more detailed resource management activities.

Data from the Gap Analysis Project, which is expected to be completed nationwide near the end of this decade, can also identify lands already in public ownership where changes in land use might improve protection for non-listed candidate species or recovery of listed threatened or endangered species. Finally, Gap Analysis information will allow analyses of resource status across state boundaries and within large ecological units or eco-regions. These kinds of information will provide resource managers dealing with endangered species a proactive management tool allowing them to anticipate resource problems and act in advance, potentially averting listing and aiding recovery.

To ultimately reduce the conflicts over endangered species and the loss of biological diversity, resource managers must move into an anticipatory approach. At the current rate of funding and effort, new species are being listed as endangered or threatened more rapidly than species on the list are being recovered; unless circumstances change dramatically, species will become extinct more rapidly than they can be reviewed and listed. Clearly, resource managers must make use of new tools and concepts to avoid this loss. Given these threats, the time is right to implement the concept of ecosystem management. The time to protect a species is while it is still common rather than after it is in danger of extinction. While the goal for conservation of biological diversity should remain to protect individual species, a proactive process of ecosystem management can best achieve this goal.

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Dr. Edward T. LaRoe is Director, Cooperative Research Units, U.S. Fish and Wildlife Service, Washington, D.C. These comments reflect his personal opinions and do not represent the position or policy of the U.S. Fish and Wildlife Service.

Editor's note:

In December 1992, about one month after Dr. LaRoe submitted this article to the UPDATE, the U. S. Fish and Wildlife Service (USFWS) reached an out-of-court settlement regarding the backlog in listing decisions for candidate species under the Endangered Species Act. Under the agreement, USFWS will decide whether to propose for listing approximately 400 candidate plants and animals over the next four years.

The agreement also formalized a Service commitment to emphasize, where possible, multiple species listings or proposals that address entire ecosystems, instead of a species-by-species approach. In addition to being more cost-effective, these methods allow USFWS to focus on the needs of plants and animals in their communities as a whole, rather than as isolated individuals.

The Contemporary Paradigm in Ecology and its Implications for Endangered Species Conservation

by

Peggy L. Fiedler, Robert A. Leidy, Richard D. Laven, Norman Gershenz, and Leslie Saul

The classical paradigm in ecology, with its emphasis on the stable state, its succession of natural systems as closed and self-regulating, and its resonance with the nonscientific idea of the balance of nature, can no longer serve as an adequate foundation for conservation. The new paradigm, with its recognition of episodic events, openness of ecological systems, and multiplicity of locus and kind of regulation, is in fact a more realistic basis for conservation planning and management.

- Pickett, Parker and Fiedler 1992

The contemporary paradigm in ecology, patch dynamics and its logical companions, ecosystem and landscape ecology, quite recently has received significant attention in the ecological and conservation literature (e.g., Botkin 1990, Gosselink et al. 1990, Keiter and Boyce 1991, Pulliam and Danielson 1991, Salwasser 1991, Walker 1992, among many others). This is because, as we approach the reauthorization of the Endangered Species Act in the coming months, it is clearly apparent that not only is a single-species approach to conserving rare and endangered species logistically and financially impractical, but this approach has a theoretical scaffolding that is rapidly being replaced.

The older "equilibrium" paradigm in community organization (discussed briefly below) has provided the ecological science for all existing U.S. environmental legislation. As such, it afforded conservation biologists the luxury of defining clear targets for management—presumed climax communities with a known species complement and organization, or explicitly defined, successional habitats for wildlife reintroduction. In retrospect, these targets may have been unrealistic and even undesirable. Thus the conservation community has come to realize that a steady-state is not necessarily the appropriate model for long-term endangered species preservation, and that in assuming that it is, we might well consign many other rare or threatened species to extinction (or at least to dangerously depleted population numbers). There is no better example of the ramifications of the application of this inappropriate model than the fate of the African elephant and the environmental devastation at Tsavo National Park, Kenya (Botkin 1990).

The conservation community has come to realize that a steady-state is not necessarily the appropriate model for long-term endangered species preservation...

In this article we discuss aspects of the current thinking in the science of ecology that now lead us to a revised approach to conserving endangered species. We also provide context by discussing what isn't considered "new" in the ecology of conservation science, and whether or not this current thinking is useful for *in situ* as well as *ex situ* species preservation. Provided are brief examples of how the new paradigm has been or should be adopted in endangered species conservation, and how it forces a new orientation with different management objectives.

What is the Contemporary Paradigm?

Since the late 1970s, ecologists have recognized that ecological systems do not always behave in patterns predicted by the prevailing equilibrium theories of community dynamics. At that time, scientists proposed that natural disturbances not only could significantly influence the structure and function of ecological systems, but that many forms of disturbance, such as fires, hurricanes, droughts, lava flows, etc., were critical for an ecosystem's regeneration and maintenance. Thus it became clear that a great variety of disturbances and physical processes (e.g., flooding) were organizing elements in the composition and structure of biotic communities on several scales, from genes to landscapes. Most instrumental in bringing into focus this shift in ecological paradigm were the works of Pickett and his colleagues (Pickett and Thompson 1978, Pickett and White 1985), White (1979, White and Pickett 1985), and Simberloff (1982).

Specific fields of study within the contemporary paradigm include patch dynamics, ecosystem ecology, and landscape ecology. Although such approaches to the study of natural phenomena were in existence well before the last decade, recently there has been an enormous emphasis in ecological research to explain natural phenomena at the larger scales defined by these disciplines.

Quite recently, despite considerable philosophical resistance and institutional inertia, land managers have attempted to incorporate this new paradigm within their management philosophies and designs. For example, Goldstein (1992:184), in his cogent discussion of an ecosystem approach to the management of the Greater Yellowstone Ecosystem, suggests that there are three basic goals to an ecosystems management approach. These are: "[1] maintaining plant and animal populations and restoring species eliminated by humans, [2] monitoring such ecological processes as water and air quality, vegetation dynamics, and wildlife populations trends, [and] [3] integrating long-term sustainable human economics within this framework."

The physical and biological processes that structure and sustain communities, ecosystems and landscapes are emphasized, even targeted for monitoring, in this reorientation of land management. It remains to be seen whether such a large philosophical and programmatic shift can occur within a time frame adequate to restore or maintain the Greater Yellowstone Ecosystem and elsewhere.

What isn't the Contemporary Paradigm?

Despite a long-standing lack of consensus about the controlling factors of community organization (e.g., Elton 1930), the prevailing theme in ecology has been that natural systems are best described as "closed" with stable equilibria, and are regulated by such interspecific interactions as competition, predation, or both. Equilibrium models have shaped the preservation and management of our endangered species to date, and perhaps this is best illustrated by our use of island biogeography theory (MacArthur and Wilson 1967) in the theoretical design of nature reserves (Diamond and May 1976). In its simplest terms, all else being equal, larger areas will harbor more species than smaller areas, and will have lower rates of extinction and higher rates of colonization.

The proposed use of this theory, however, led to considerable controversy about the reliance on the species-area equation, "turnover rates", and thus the size and number of reserves (Simberloff and Abele 1976a, Diamond 1976, Terborgh 1976, Whitcomb et al. 1976, Simberloff and Abele 1976b).

However, recent reserve design strategies have been proposed on a regional or landscape scale. For example. Miller et al. (1987) proposed a strategy for the placement of preserves based on a computer analysis of environmental correlates of rare vascular plant species richness. They argue that our knowledge of the dynamic processes governing insularity of rare plant species is inadequate for incorporation into regional conservation planning.

Others have called for a network biosphere design linked by ecosystem and landscape dynamics (Dyer and Holland 1991), and still others have suggested that certain habitats rich in endangered species such as coastal wetlands cannot be protected until the development of ecosystem processes (e.g., plant productivity, food chain support) are accelerated by active management (Zedler 1991).

How to Manage Process, Not Species

What does it mean to manage "process"? The answer is not intuitive, and is best illustrated by examining two well-known abiotic influences on vegetation—fire and water. Fire has long been accepted as an organizing influence on a vast number of plant communities, and the timing, frequency and intensity of fire influences compositional and structural changes that occur over time within a community. And too, many plant communities are defined by the presence and amount of water, and the nature of their hydrologic regime in many ways determines the presence, abundance and distribution of the associated biota.

Fire. Although the equilibrium paradigm considered natural disturbances such as fire as a relatively unique event that prevents the achievement of climax conditions, the ecological community now largely accepts that fire has an organizing influence on a vast array of ecosystems (e.g., Southern California chamise chaparral, Sierran giant sequoia, Rocky Mountain aspen and lodgepole pine, etc.). As such, long-term ecosystem dynamics, and the resultant landscape configurations, are affected. When managing from a process perspective, one must define a landscape configuration and embrace the appropriate variations in frequencies and intensities of fire that determine that configuration. A great deal of the diversity we see in ecosystems is a function of this variation in frequency and intensity.

Of the more familiar examples of fire-regulated ecosystems are those defined by wiregrass (*Aristida stricta*) within the southeastern United States. Disturbance processes that maintain and rejuvenate wiregrass ecosystems include fire as well as drought, windthrow, and lightening (Bridges and Ozwell 1989). In wiregrass/longleaf pine (*Pinus palustris*) savannas, lightning strikes are transformed into the surface fires carried by wiregrass and pine litter, preventing the establishment of tree species competitive with longleaf pine (Platt et al. 1988).

Thus surface fires not only maintain the dominant species, but the rare and associated species as well. For example, Hardin and White (1989) documented an astonishing 191 rare vascular plant taxa that occur in ecosystems in which wiregrass is a dominant component. In addition, the gopher tortoise (*Gopherus polyphemus*) is a keystone vertebrate in the wiregrass/longleaf pine sand hills that supports some 362 commensal animal species.

A great deal of the diversity we see in ecosystems is a function of...variation in frequency and intensity

It has been argued that the entire southeastern coastal plain should be considered as a whole in its conservation strategy (Noss 1988, 1989), despite a landscape of several plant communities, soil types and moisture regimes. This is in large part because most of the wiregrass-dominated ecosystems have been converted to other land uses or are otherwise seriously degraded—as much as 98 percent of the longleaf/wiregrass ecosystems has declined since presettlement times (Ware et al. 1989). In terms of management of process, prescribed burning during the summer months will maintain wiregrass ecosystems (Duever 1989).

Single-species management of this (and other) fire-prone ecosystems would simply be inappropriate, given the vast number of rare and/or endangered associated species, and would likely jeopardize landscape heterogeneity. By managing fire as a process, we are assuring the perpetuation of naturally diverse landscapes on several spatial scales.

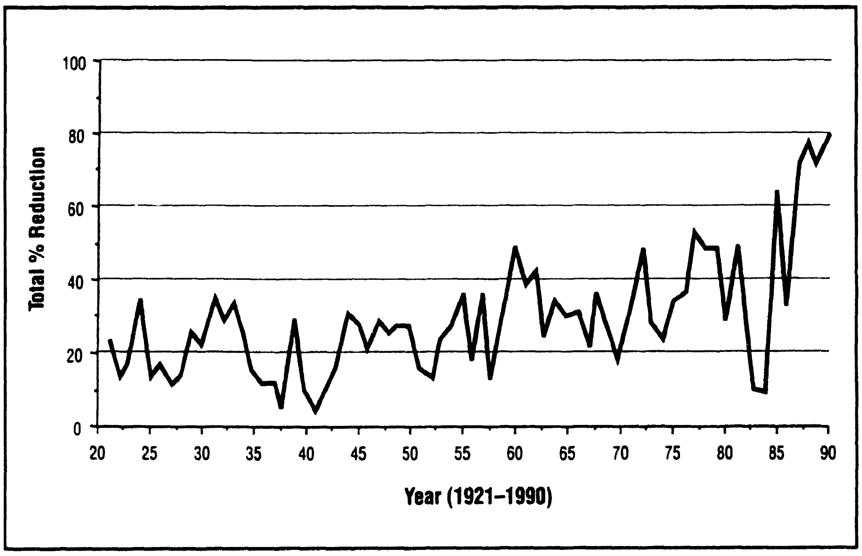

Figure 1. Reduction in the Sacramento/San Joaquin Delta outflow caused by upstream diversions, in Delta users, and Delta exports, 1921-1990 (From Monroe and Kelly 1992).

Water. The physical processes of water flow in the world's large rivers and estuaries serve as potent examples of processes that control the structure and function of ecosystems. For example, manipulation of natural water runoff patterns to California's San Francisco Bay/Sacramento-San Joaquin River Delta Estuary (Delta/Estuary) has modified significantly the natural hydrodynamic and biogeochemical processes that influence the Delta/Estuary's wetland and aquatic communities. Freshwater diversions and reservoir storage have altered natural seasonal variation (e.g., timing) in flow patterns, as well as resulted in reductions in total annual flow to the Delta/Estuary by greater than 50% (Figure 1; Monroe and Kelly 1992). Water storage in large upstream reservoirs during the winter and spring months has reduced Delta/Estuary outflow during spring and early summer by as much as one-third in normal runoff years, and up to 85% in dry years, of what would be expected without such diversions and storage (Figure 2; Meiorin et al. 1991).

Freshwater diversions also have severely altered the hydrology and hydraulics of the Delta/Estuary to the point where community and ecosystem level effects are readily observable. Altered biochemical processes have led to: (1) declines in the abundance of phytoplankton and zooplankton populations, altering food webs, (2) shifted vegetation composition and distribution patterns, (3) increased entrainment of fishes in diversions, (4) increased geographic range of exotic species, and (5) resultant decline of the native fish communities (Herbold et al. 1992).

Recent precipitous declines in various components of the Delta/Estuary's fish community are largely attributable to severely altered hydrodynamic processes (Table 1). Particularly vulnerable are fishes that spawn in spring and early summer when water diversions for agricultural uses are greatest. Interestingly, fish species in decline show a wide range of food preferences—evidence that altered flow regimes are influencing multiple trophic levels upon which these species depend. Finally, species that are wholly confined to the Delta/Estuary, (e.g., Delta smelt (*Hypomesus transpacificus*) and Sacramento splittail (*Pogonichthys macrolepidotus*)), have experienced the most precipitous population declines over the short term.

Recovery of individual fish species constituting these communities will necessarily require the management of hydrodynamic processes to more closely simulate the historical timing, frequency and intensity (i.e., amount) of freshwater flows through the Delta/Estuary. Such an approach recognizes that the entire ecosystem is in decline, and this can be addressed best by managing processes that are responsible for these declines.

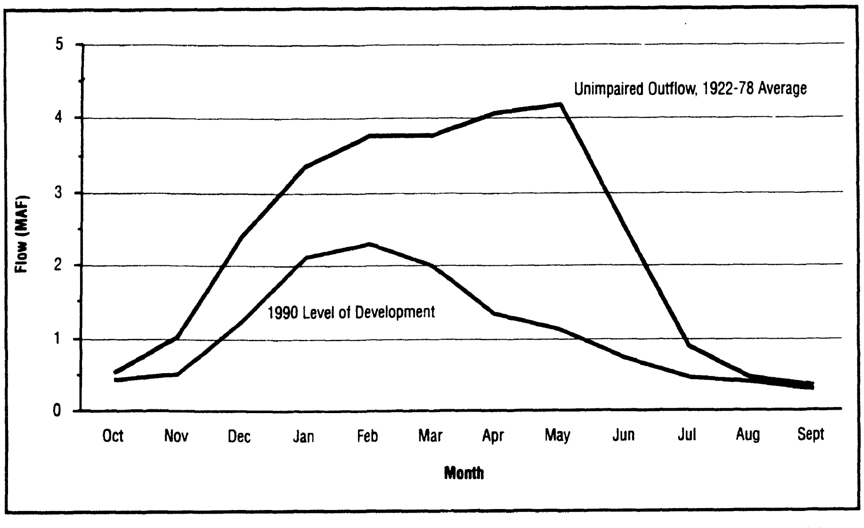

Figure 2. Seasonal Sacramento/San Joaquin Delta outflow under unimpaired conditions and present level of development (From Monroe and Kelly 1992).

Interestingly, this approach of recovering entire assemblages of threatened organisms by managing physical processes such as water flow was taken in a recent petition by the Natural Heritage Institute, the American Fisheries Society, and several other conservation organizations to list simultaneously the longfin smelt (*Spirinchus thaleichthys*) and the Sacramento splittail under the Endangered Species Act (NHI 1992). The listing of the longfin smelt and the Sacramento splittail, when considered with other fish species already receiving (or about to receive) some degree of protection in the Delta/Estuary (e.g., winter-run chinook salmon (*Oncorhynchus tshawytscha*)), Delta smelt; Table 1), provides a cogent argument for managing processes to affect recovery of a declining ecosystem. Single species recovery efforts are limited by issues of scale in addressing recovery efforts.

Recent legislation passed in the U.S. Congress in October, 1992, dedicated 800,000 acre-feet of water per annum from the California's Federal Central Valley Project to, among other things, protection of fish and wildlife, including endangered species, in the Delta/Estuary. It remains to be seen whether this amount of water will be sufficient to slow or reverse trends in the decline of fish species in the Delta/Estuary, or how best this water would be used in terms of the timing of releases to affect hydrodynamic processes.

In Situ Conservation in the *Ex Situ* Community

Zoological parks and gardens, once disparate collections of wild-caught animals exhibited for recreation, changed their focus during the 1960s to self-sustainability, and subsequently shifted again in the last two decades to focus on captive propagation and management of individual species for *ex situ* conservation.

To address the concerns of single-species preservation, zoos created Species Survival Plans (SSPs), Taxon Advisory Groups (TAGS), Faunal Interest Groups (FIGS), and the Captive Breeding Specialist Group (CBSG) (Willis et al. 1992). Additional conservation programs spawned from zoos, such as GASP (Global Action Species Plan), SOS (Save Our Species), CPR (Captive Propagation Rescue)—acronyms that mirror emergency room efforts. To date, emphasis has been on "flagship species," primarily megavertebrates. This has, in some cases, encouraged *in situ* management practices detrimental to other less visible species, and to the overall diver-

Table 1. General habitats and food sources of representative fishes, with recently declining populations, of the San Francisco Bay and the Sacramento-San Joaquin Delta/Estuary. (Adapted from Table 4 of Monroe and Kelly 1992).

SPECIES	SPECIES ORIGIN	SPAWNING TIME	SPAWNING LOCATION	NURSERY AREA	MAJOR FOOD SOURCE - ADULT	MAJOR FOOD SOURCE - JUVENILE	USE OF BAY OR DELTA
Longfin smelt, *Spirinchus thaleichthys*[1]	Native	Winter, Spring	Rivers	Delta, Bay	Plankton	Plankton	Bay - Nursery, Residence
White Sturgeon, *Acipenser transmontanus*	Native	Spring	Rivers	Estuary	Plankton	Plankton	Delta - Residence
Chinook Salmon, *Oncorhynchus tshawytsha*[2]	Native	All months; greatest numbers in fall	Rivers, Upper Delta	Rivers	Fish, Plankton	Plankton, Insects	Delta - Nursery, Migration; Bay - Migration
Delta Smelt, *Hypomesus transpacificus*[3]	Native	Spring	Delta	Delta, Suisun Bay	Plankton	Plankton	Delta - Spawning, Nursery, Residence
Splittail, *Pogonichthys macrolepidotus*[1]	Native	Spring	Delta	Delta, Suisun Bay	Plankton	Plankton	Delta - Spawning, Nursery, Residence
White Catfish, *Ictalurus catus*	Introduced	Spring, Summer	Delta	Delta	Benthos	Benthos	Delta - Spawning, Residence
Striped Bass, *Morone saxatilis*	Introduced	Spring	Rivers, Delta	Delta, San Pablo Bay	Plankton, Benthos, Fish	Plankton	Delta - Spawning, Nursery; Bay - Nursery

[1] Petitioned for listing under the Endangered Species Act (ESA) on November 5, 1992.

[2] Winter-run chinook salmon listed as a threatened species under the ESA. Both spring-run and fall run populations continue to decline dramatically as well.

[3] Candidate for listing under the ESA.

sity of the habitat, as in some tiger reserves in India and Nepal (Dolan 1991).

One serious concern in the zoos' current approach to endangered species conservation is the small number of species that can and do receive *ex situ* protection. Only approximately 4200 species of vertebrates are housed in zoos today, and only about 1200 species have been bred successfully in captivity. And although great advances in captive husbandry and the reproductive biology of rare, captive species have been made, taxa in zoos and reintroduction programs represents only a small fraction of less than 1 percent of the animal species found on earth. Stretched to full capacity, all the zoos in the world could sustain viable populations of at best only 900 SSP species by the year 2000 (Seal 1985). Today, SSPs include only 64 species.

The expense of single-species *ex situ* conservation versus ecosystem *in situ* conservation...is possibly the strongest argument against continuing only in this direction

In addition, the problems of single species propagation and reintroduction are many, including: (1) vulnerability of captive bred reintroductions to disease and exposure of wild populations to disease, (2) loss of genetic diversity, (3) low survivorship, (4) loss of suitable habitat, (5) use of management practices detrimental to other less visible species and the overall habitat diversity, (6) conflicting state and local politics, (7) an unstable world economy, and (8) exorbitant costs.

For example, the cost of maintaining the whole Serengeti ecosystem is currently $500,000 US/year. It costs the same amount to maintain viable populations of just five species of primates in North American zoos (Western 1987). The cost of developing one SSP for a gibbon species is $250,000, and covers a period of18 months (Tilson 1992, pers. comm.). Research in the wet evergreen forests of the Western Ghats, India, has shown that it would cost $30,000 to protect a 250 km^2 area harboring 250–500 individual wild lion-tailed macaques. In contrast, it would take $150,000 to reintroduce 12 captive bred macaques (Karanth 1992). Thus the expense of single-species *ex situ* conservation vs. ecosystem *in situ* conservation strategies is possibly the strongest argument against continuing only in this direction. Zoos must now shift yet again to embrace an even broader conservation approach, in part driven by, and guided by, the contemporary paradigm in ecology.

The most relevant example of zoos' response to this conservation challenge is the Ecosystem Survival Plan (ESP), founded in 1988 within the zoo and aquarium community (See article by Gershenz and Saul pages 61-62 in this issue). This program has four main goals, of which three are important here. First, the ESP encourages and helps facilitate the incorporation of an ecosystem approach in zoo and aquaria conservation programs, in addition to existing single species programs. Second, ESP encourages *in situ* conservation by providing a means to develop funding for ecosystem conservation efforts and thereby provide the conduit for more institutions to participate without compromising their operational needs. Lastly, the ESP strives to educate the public and institutional staff about ecosystem-level conservation approaches and the impact of their participation and actions.

To date, 56 zoos and aquariums and their visitors have joined together in this consortium to participate in *in situ* ecosystem conservation. The first projects included the establishment of Guanacaste National Park (247 square miles) and La Amistad National Park (480,000 acres) in Costa Rica, and the Rio Bravo Conservation Area (152, 000 acres) in Belize. Guanacaste National Park alone protects 100 species of mammals, 500 species of birds, 200 species of amphibians and reptiles, and very importantly, 3,000 species of plants and 30,000 species of insects along with the dynamic processes that are integral to the ecosystem.

Like the new paradigm in ecology, the ESP program does not surplant or compete with the older conservation programs, but rather complements them. In short, it is considerably more economical to conserve species in nature and the biogeochemical processes that support them, than to do so in captivity (Woodruff 1989).

Conclusions

What, then, are the implications of the contemporary paradigm in ecology for the conservation and management of endangered species? First, we must begin to appreciate that natural systems are not simple and linear; their paths of vegetation change are not necessarily steady and neatly progressive. Secondly, we need to learn to manage nature as mutable and perhaps malleable, but not as static and easily definable objects. Finally, as it becomes evident that our conservation approaches of the past have been oversimplified, we must appreciate that single-species programs should only be implemented as part of a more holistic effort to preserve species in their natural habitats and ecosystems (Willis et al. 1992). We must look at large scale solutions that encompass multiple approaches and fiscal wisdom in order to advance the goals of our global conservation efforts.

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The Landscape Ecosystem Approach and Conservation of Endangered *Spaces*

by

Burton V. Barnes

Focused on spaces as well as species, the landscape ecosystem approach provides a holistic ecological framework for preserving, conserving, and managing segments of the ecosphere. The approach, as it has been applied in Michigan, has its roots in the southwestern German state of Baden-Württemberg where a comprehensive yet simple ecological method of ecosystem classification and mapping was developed. The ecological approach is well suited for conserving rare and endangered species, preserving and maintaining ecological diversity and biodiversity, and preserving and restoring natural landscapes.

Endangered species and biodiversity are popular concepts. They typically identify for most of us the most important objects in the world—organisms—rather than the ecosystems of which they are one part. Humans and other organisms are dependent and integral parts of the largest "space" we know—the ecosphere. This ecocentric viewpoint, the ecological foundations and theory of the landscape ecosystem approach, as well as insights to its application in conservation and ecosystem management, are well documented in the writings of J. Stan Rowe, Professor Emeritus of the University of Saskatchewan. In practice, landscape ecosystems have been identified, classified, described, and mapped in the field for over four decades in Canada and Germany. This research provides a geographic and ecological framework for use in conservation of ecosystems and organisms at any designated spatial scale.

Our focus [shifts] from animals, plants, soils, esthetics, and other properties of the earth's skin to three-dimensional landscape and waterscape ecosystems...

I will briefly outline below the rationale of the landscape ecosystem approach and define landscape ecosystems drawing primarily from the work of Rowe. I will sketch briefly how we came to adopt the specific approach we use and describe how we go about identifying and mapping landscape ecosystems in the field. I will describe an example of the relationship of the rare and endangered species, the Kirtland's warbler, to landscape ecosystems of its summer breeding grounds.

A Holistic Approach

Using an ecosystem approach means that we focus on wholes, not parts (Rowe 1992)—shifting our focus from animals, plants, soils, esthetics, and other properties of the earth's skin to three-dimensional landscape and waterscape ecosystems that produce these valuable things. The largest of these volumetric units that we know is the earth, i.e., the ecosphere. And nested within it are macro-level, meso-level, and micro-level ecosystems that range from continents and seas to the local landscape type consisting of an atmospheric layer over an earth/water layer with organisms sandwiched between at the surface. However, the gas, solid, and organic phases of the ecosphere are not separate. As Rowe (1992) observes:

> "Misled by our dominant sense of sight that operates by separating objects in space, we have divided the Ecosphere into fragments in various ways such as air, water, sediments and organisms or —more commonly and self-centeredly —into 'people' and 'environment.' But we have missed the most important way to divide the Ecosphere for purposes of understanding, management and admiration. The division that makes most ecological sense breaks the air/water/landform skin of the Earth, at different scales according to purpose, into three-dimensional chunks; geographic ecosystems that include all the essentials: air, water, sediments and soils along with their organisms, yielding the equivalent of giant terrariums and giant aquariums."

In research at the University of Michigan, with teams of graduate students, we have attempted to apply and test this landscape ecosystem approach.

The German Connection

The Baden-Württemberg method, initiated in 1947, features an interdisciplinary team approach (Barnes 1984). As personnel of the state forest research station in Stuttgart, they pioneered the integration of multiple factors (forest history, pollen analysis and paleoecology, geology and geomorphology, geography, climate, soils, vegetation) to identify, classify, describe, and map forest ecosystems. Besides the physical or abiotic site factors, vegetation (pre-settlement natural vegetation of the Period IX of Firbas, 1952), and soil biota were also taken into account. Thus they recognized the multiple layers and volumetric nature of whole ecosystems.

Besides the multi-factor approach, the Baden-Württemberg team also pioneered the use of a comparative, hierarchical approach in classification and mapping. They used multiple scales (i.e., four hierarchical levels) to characterize the landscapes of the state. Thus from the outset they were doing what we call today "regionalization" (Rowe 1991)—partitioning landscapes from above ("top-down" subdivision) as well as aggregation from below (Rowe 1979). For purposes of land preservation or for ecosystem management and environmental monitoring one cannot overemphasize the importance of using multiple scales and particularly a "top-down," mapping approach. In this issue, Dennis Albert (pages 20-25) has described the significance of this approach.

A third major contribution of the German workers was to develop the method of Ecological Species Groups (Sebald 1964, Schlenker 1964, Dieterich 1970) to employ the total vegetation of an area in distinguishing ecosystem types. In this method, one uses groups of species such as herbs, shrubs, mosses (because of similar ecological requirements or tolerances) to indicate certain site-factor complexes, e.g. soil moisture and drainage conditions, soil nutrient relations, light intensity, and soil-reaction (acid vs. basic) gradients. Groups of species tend to be more useful and reliable than single indicator species because reliance is placed on several species. A given ecosystem type is typically characterized by several ecological species groups as well as by a suite of more or less distinctive physiographic, microclimatic, and soil factors.

About the same time, research workers in Canada under the leadership of G. A. Hills, developed a similar system, a "Total Site" approach, using multi-factors at several hierarchical levels (Hills 1952, 1960, 1977; Hills and Pierpoint 1960).

Regionalization and Classification

What is often called "classification" has two separate but related steps that should be distinguished. The first is the *partitioning* of the landscape into units and the second is the *logical grouping* of the resulting parts (Rowe 1991). In the first step, ecosystem types are identified and distinguished by relevant criteria from their surrounding ecosystems. This process of differentiating and mapping units of the landscape is called "regionalization" by geographers (Bailey 1976). At either a broad or local scale this process typically proceeds from above or "top down."

The second step, logical grouping or aggregation of the units based on similarities, is *classification*. What is called "site classification" in the forestry literature may or may not include both regionalization (mapping) and classification. In our work we have used both regionalization and classification in developing a formal "classification" and map for each area.

Distinguishing Among Landscapes

In addition to using the landscape ecosystem approach in teaching, we began in 1976 to conduct research in the field to test and apply a modified version of the Baden-Württemberg method. Since then I have worked with teams of graduate students to develop an approach applicable for local landscapes up to about 25,000 acres in size. In addition, we have developed a regional landscape ecosystem classification and map for the state of Michigan (Albert et al. 1986; pages 21-22 in the article by Albert in this issue).

Fundamentally, the goal is to identify, classify, describe, and map the basic units of nature. The initial research in developing and testing the approach was done at the Cyrus H. McCormick Experimental Forest [see Figure 1, and Box on page15] and the Sylvania Recreation Area in Upper Michigan.

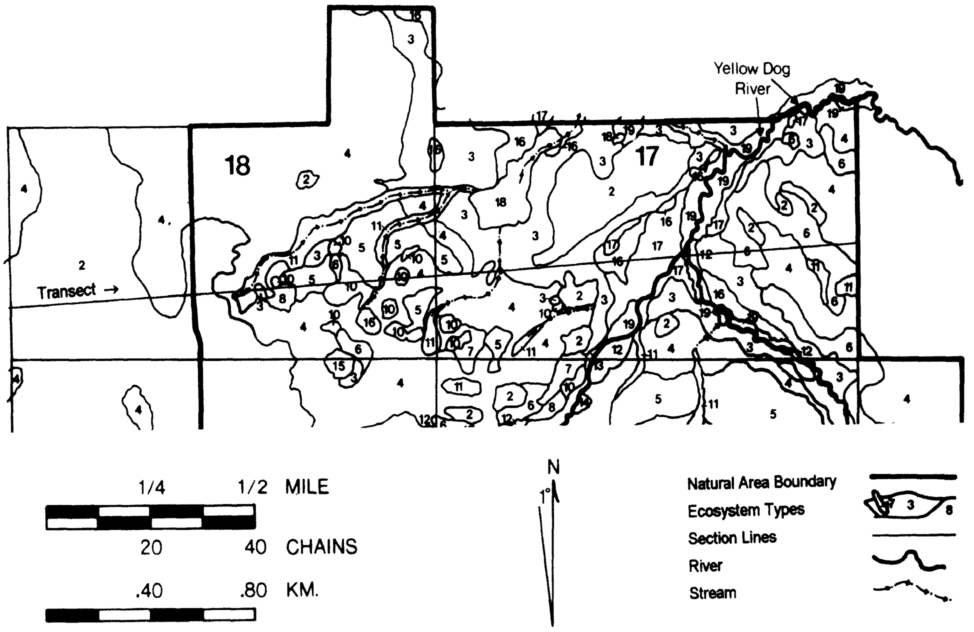
The ecosphere can be segmented into geographic ecosystem types at several scales. At the local scale, these are the basic functional units of nature, and they form a spatial mosaic over the landscape. Some ecosystems are encountered in relatively neat packages, as a bog bounded by upland on all sides. More typically we carve them out of the landscape continuum by the use of appropriate criteria. Although this subjectivity may be a stumbling block for some to the acceptance of landscape ecosystems, it need not be (Rowe 1961). Soils are a good analogy; they are an accepted

Continued on page 16

Figure 1. The McCormick Experimental Forest is a sugar maple *(Acer saccharum)* dominated forest.

A Local Ecosystem Map

The Cyrus H. McCormick Experimental Forest, of approximately 17,000 acres, is primarily old-growth northern hardwood and conifer forest. We developed an ecosystem classification and map for the 4,200-acre natural area and then completed the mapping of the entire area using a combination of aerial photographs and ground checking (Barnes et al. 1982).



(Figure reprinted from *Journal of Forestry* (vol. 80, no. 8) published by the Society of American Foresters, 5400 Grosvenor Lane, Bethesda, MD 20814-2198. Not for further reproduction.)

The map above shows a part of the local ecosystem type map of the McCormick Experimental Forest. A transect running roughly west to east (line above the horizontal E-W section line) illustrates the pattern of ecosystem types in the northeast part of the area. On the west an extensive flat, infertile outwash plain (ecosystem type 2) is dominated by nearly pure, low stature sugar maple (*Acer saccharum* Marsh.). On the east, a rocky ridge, typical of the Michigamme Highlands, runs approximately northwest to southeast. It is identified by the small, recurring ridge-top segments of ecosystem type 10 and the thin-soil ecosystem types 7 and 8, that are often adjacent to such rock outcrops. On the northern slope of the ridge, ecosystem types 4 and 5 predominate. Type 4 typically occurs on sandy upper and mid-slopes and type 5 on loamy lower slopes. These ecosystems are dominated by almost pure sugar maple communities, yet they differ in typographic position, soil, ground cover species (ecological species groups), and certain overstory species.

As the terrain levels out just east of the north-flowing stream, ecosystem 3 prevails on sandy, infertile soil with a high water table. Conifers, especially hemlock (*Tsuga canadensis* (L.) Carr.) and balsam fir (*Abies balsamea* (L.) Miller), together with red maple (*Acer rubrum* L.) dominate this gently sloping transition zone to the wetlands of the Yellow Dog River. Adjacent to the river are the wetland ecosystems: acid (ecosystem 18) or circumneutral (ecosystem 19) hardwood-conifer swamps and streamside alder (*Alnus rugosa* (Du Roi) Spreng.) (ecosystem 21).

East of the river, and bordering the transition ecosystem 3, is a characteristic alternation of ecosystems: steep, sandy southwest slopes dominated by white pine (*Pinus strobus* L.) (ecosystem 6), and steep, sandy, northeastern slopes dominated by sugar maple (ecosystem 4). These types occur on a series of ice-contact features. The striking difference in vegetation on the same geologic feature and soil parent material illustrates the strong effect of aspect and microclimate in determining vegetational composition.

Continued from page 14

object of scientific study although their boundaries are fixed only by definition.

In the field, one can readily identify and distinguish, as different landscapes, sandy beach ridges supporting jack pine and a nearby peat bog of black spruce. These types differ not only in their plants and animals, but equally important in their form of the land (rolling upland ridges vs. depression), atmosphere (hot vs. cold), and soil parent material (sand vs. peat). Each such ecosystem type not only has spatial *structure*, a predictable position in space and different form, but also complex interactions between its atmospheric, physiographic, soil, and biotic components that we term its *functioning*.

In addition, each of these systems through time undergoes successional changes. These are most obvious in plants and animals as they are influenced by abiotic changes of macro-and microclimate and soil and natural forces such as fire and windstorm. At a given place on the earth's surface different ecosystems have occurred there as a result of the changing interactions of the relatively stable physiography and the more labile components of biota, climate, and soil. Thus we must think of landscape ecosystems in both spatial and temporal scales. And for relatively brief chunks of time, 100-200 years, we can provide useful maps and descriptions of the landscape ecosystems centered around the physiographic features (specific land form and parent material) of a location-specific site.

Thus, following Rowe (1961) we define any single perceptible ecosystem as "a volume of land and air plus organic contents extended areally over a particular part of the earth's surface for a certain time."

How are local landscape ecosystem types differentiated, classified, and mapped using the multi-factor method? No single rigid method is appropriate because of the enormous ecological diversity of different landscapes. However, a general approach is universally applicable. Our job is to sort out the mosaic, differentiating the meaningful ecosystems and in highly disturbed places the sites of landscape ecosystems (Rowe 1991). The methods we have used have been published: McCormick Experimental Forest (Barnes et al. 1982, Pregitzer and Barnes 1984); Sylvania Recreation Area (Spies and Barnes 1985a, 1985b); oak ecosystems of southeastern Michigan (Archambault et al. 1989, 1990); Huron Mountains (Simpson et al. 1990). Readers are directed to the Simpson et al. (1990) paper for the most detailed description of field methods.

Field Methods

To start with we'll assume that the landscape under consideration is a known part of the next higher level in the regional classification of ecosystems and has a relatively homogeneous macroclimate and gross physiography. The first part of the work is to obtain, study, and integrate all information available on the climate, physiography, geology, geomorphology, soils, and vegetation of the area. A first approximation of the classification can be derived by the integration of knowledge of these factors together with a general field reconnaissance of the area.

Areas of markedly different physiography can be distinguished as a starting point. For example, in the glaciated terrain of the Lake States, wetland areas can be distinguished from upland (dryland) areas. And water-laid land forms (flat topography of outwash plains and hilly terrain of ice-disintegration features) can be distinguished from rocky, mountainous terrain or ice-laid glacial till. Thus, at the outset several broad groups of ecosystems can be identified for detailed examination in the field.

Armed with such a first approximation as a working hypothesis, field research is conducted to test the hypothesis and develop a second and more detailed approximation of the classification. Such a "top down" approach of partitioning the area is important early in the research. It is then followed in the field by examination of small, individual types.

Of the ecosystem components, physiography (often termed landform) is the most important in identifying, classifying, and mapping local landscape ecosystems. Physiography is an abbreviation for physical geography which is defined as the surface features of an area (Neufeldt and Guralnik 1988). In our research, physiography is conceived as being characterized by a suite of factors that not only give spatial structure to landscapes, but significantly control ecosystem functioning.

A given landscape ecosystem type would be characterized by these factors. They would include: (1) the specific physiographic feature or land form (mountain, outwash plain, kettle, river terrace, etc.) and in turn many specific characteristics (land form size and shape, slope shape, slope aspect, degree of slope, position on slope, etc.), (2) parent material of the specific land form (rock type, soil particle size, etc.), (3) position of the land form in relation to other land forms, and (4) elevation above sea level. *A priori*, physiography provides the best means of distinguishing ecosystem units at the local level because it is the most stable of ecosystem components and strongly controls regional and local climate, soil moisture, and related nutrient conditions.

In the field, we use an iterative method to continually test and revise the classification by: reconnaissance (over the whole area, at specific points, and along transects), point sampling along transects, plot taking (detailed data taken from temporary or permanent plots), data compilation and study, data analysis, and test mapping. Each successive approximation of the classification is revised by a combination of these methods. Test mapping is typically delayed until the delineation of types is relatively well developed and the physiographic and soil factors and ecological species groups that distinguish the different ecosystems are well understood.

In practice, a team of ecologists would conduct reconnaissance throughout the area, take transects along important topographic gradients of the area, and establish temporary or permanent sample plots. Data on ecosystem components (physiography, soil, vegetation) are taken at points systematically along transects and in sample plots that are established in a stratified random way. We use all ecosystem components simultaneously in the field to examine our working hypothesis of different ecosystem groups and to identify types within groups. In many, if not most cases, the combination of physiographic, soil, and vegetative factors allows us to identify the different ecosystem groups and types and their boundaries.

When we identify an area homogeneous in physiography, soil, and vegetation (i.e., a putative ecosystem type) we establish a sample plot (typically 15 x 30 m) by randomly determining azimuth and distance. When we perceive this same type recurring again in the landscape we sample it again, thereby accumulating a series of plots that characterize what appears to be, by the presence of an entire suite of physiographic, soil, and vegetative factors, an identifiable and mappable ecosystem type. The data are compiled and similarities and differences among putative ecosystem groups and types are examined throughout the field season. Based on our understanding of all factors, types are discarded or merged with other types.

Throughout the field reconnaissance and data taking, ecological gradients of moisture and drainage, nutrients, soil reaction, and light intensity are studied in relation to the occurrence of groundcover species. Ecological species groups (Spies and Barnes 1985b; Archambault et al. 1989) are thus developed through field observations and data analysis.

At some point in the iterative process, ecosystem test mapping is conducted to determine if we can actually identify and map the types we have distinguished on paper. As Rowe (1980) notes: "The heart of 'ecological classification' is the preparation of maps." Actually it is the process of mapping and, even before actual mapping, the knowledge that the classification must be mappable and explainable, that directs and shapes the classification process and the integration of ecological components. To test the classification in the field, we go through area after area where decisions must be made and boundaries drawn or not drawn. In this process, the reliability of the classification is rigorously tested; the classification is then refined and improved on the basis of the test mapping.

Landscape Ecosystems and Conserving Species

Organisms are notable parts of ecological systems, but rare and endangered organisms cannot be preserved *per se*. As Rowe (1989) observes:

"Organisms do not stand on their own; they evolve and exist in the context of ecological systems that confer those properties called life. The panda is a part of the mountain bamboo-forest ecosystem and can only be preserved as such. The polar bear is a vital part of the arctic marine ecosystem and will not survive without it. Ducks are creatures born of marshes. Biology without its ecological context is dead."

Thus it follows that we should turn attention to the necessity of preserving endangered spaces of wilderness: natural areas, preserves, ecological reserves, and sanctuaries. In preserving the systems we preserve their notable inhabitants. The identification of whole systems by regional and local classification and mapping is useful in determining the characteristics and ecological diversity of different landscapes and their priority for preservation. Furthermore, the biodiversity of a landscape depends upon its ecological diversity.

Secondly, an understanding of whole ecosystems is gained through the process of their differentiation, classification, and mapping. Through better understanding of species-site interactions, life history of species, and their habitat requirements, we gain insights in how to manage populations of a species and its ecological system from which it is inseparable. A case in point is the Kirtland's warbler *(Dendroica kirtlandii)*.

Kirtland's Warbler in a Jack Pine Ecosystem

The Kirtland's warbler is a part of sand outwash plain, jack pine-oak forest landscapes in the north-central part of Lower Michigan, and to paraphrase Rowe, can only be preserved as such. Very little is known of its wintering ecosystems in the Bahamas so that primary attention has focused on its summer breeding grounds. Never considered an abundant bird, populations of the warbler declined from an estimated 1,000 birds in 1961 (Mayfield 1962) to about 460 birds in 1981 (Ryel 1981) and to about 400 in 1971 (Mayfield 1972).

The warbler typically nests on the ground in stands of young (8- to 20-year old) jack pine (*Pinus banksiana* Lamb.) characterized by dense patches of pines (or pines and oaks) interspersed by numerous small openings. Warblers delay colonization of an area until the jack pines reach a minimum height of 6–9 feet and leave an area when the tree crowns shade most of the openings. Although considerable research had been published on the warbler itself (two books and about 200 papers, Ryel 1981), little detailed information was known on what is termed warbler habitat.

The Mack Lake burn of May 5, 1980, (a prescribed burn that got out of control), created the possibility of studying diverse landscapes and the response of the warbler to what was to become a massive increase in summer breeding grounds. The fires covered an area of 23,830 acres surrounding Mack Lake in Oscoda County. According to Simard et al. (1983) the fire: "may have created what in 10 years will be 10,000 to 15,000 acres of prime habitat for the endangered Kirtland's warbler."

At the urging of Dr. Sylvia Taylor (see Taylor's paper in this issue pages 26-29), we undertook the study of the landscape ecosystems of the central part of the Mack Lake burn—their physiography, microclimate, soil, and vegetation that might favor colonization by the warbler. The overall objective was to establish a framework of local landscape ecosystems as the basis for understanding warbler occurrence and behavior.

We found that the outwash terrain of the Mack Lake basin was surrounded on all sides, except the west, by relatively high moraines and ice-contact land forms. The basin surrounding Mack Lake was a series of flat to rolling, pitted outwash terraces of increasing elevation, culminating in the south to sharply dissected ice-contact terrain. We distinguished arbitrarily two major landscapes,

Figure 2. Jack pine *(Pinus banksiana)* in high-level outwash, Mack Lake basin, 1986. Photo by Burton V. Barnes.

i.e., groups of ecosystems: high-level outwash and ice-contact terrain in the more southerly part of the basin and low-level outwash in the central basin surrounding Mack Lake itself. Within each of these groups of ecosystems we distinguished and described several local ecosystem types based on physiography, microclimate, soil, and ground-cover vegetation (Barnes et al. 1989; Zou et al. 1992).

The high-level outwash terrain was warmer and had several ecosystems with better soil (higher soil moisture content because of either fine sand or fine-textured bands). The low-level outwash, a large frost pocket in the center of the basin had a colder climate and ecosystems with poorer soils. When we initiated research in 1986, the jack pines and northern pin oaks (*Quercus ellipsoidalis* E. J. Hill) of the high-level terrain were in many places markedly taller, denser, and of more patchy occurrence than those in the low-level terrain (see Figures 2 & 3). Also, major differences in ground-cover vegetation were found between high-level and low-level terrain and among the local ecosystems within each.

In the first year of our research, 1986, the warblers first colonized the burn when all trees were seven years old from seed. Seventy percent of the 14 birds occupied the high-level terrain and only 30% the low-level terrain. In 1987 and 1988 about 60% of the warbler occurrence (28 birds in 1987 and 78 in 1988) was in the high-level terrain. We attributed the greater initial occurrence in the high-level terrain to markedly different physiography (including parent material) which resulted in warmer climatic conditions and better soil conditions. These in turn resulted in markedly taller jack pines, a characteristic that wildlife biologists perceive to be critical for the initial colonization of an area.

As more and more of the low-level terrain has become suitable habitat (taller jack pine and oak trees) and the warbler population increased markedly, proportionally more warblers colonized the low-level terrain. In 1991 and 1992, over 60% of the warblers (208 and 250, respectively) were found in the low-level terrain.

Not only is warbler occurrence related to the ecological conditions of the two ecosystem groups, but their occurrence could also be related to specific ecosystem types within each of the groups (Barnes et al. 1989; Zou et al. 1992). For example, Zou (1988) found that patchiness (a contagious distribution of jack pine trees as compared to a random or systematic pattern), a major criterion of good warbler habitat, was characteristic of the ecosystem types supporting warblers but not of ecosystems uninhabited by warblers.

In addition, in 1988 Zou (Zou et al. 1992) studied the occurrence of territories of 38 warblers in relation to specific ecosystem types. The warblers in 1988 (as in 1987) occurred in the same five of the 11 ecosystems identified for the area.

The territories were closest together in two ecosystems of the high-level terrain; the average distance from a singing male territory to its closest neighbor was 269 m for one ecosystem and 365 m for the other ecosystem. In contrast, a widespread ecosystem of the low-level terrain supported the most warblers, but their territories were more widely separated, 435 m. Compared to the two high-level ecosystems, the low-level ecosystem exhibited a colder microclimate, more drought-prone soil, shorter and more widely spaced trees, and less diverse ground-cover vegetation. The high-level ecosystems exhibited relatively dense populations of warblers for the initial years, but as the pines and oaks in the low-level area increased in size, a shift in the population has occurred from the high-level to the low-level landscape. Using the landscape ecosystem approach we can predict which ecosystems will be first colonized and the pattern of colonization to other ecosystems in time.

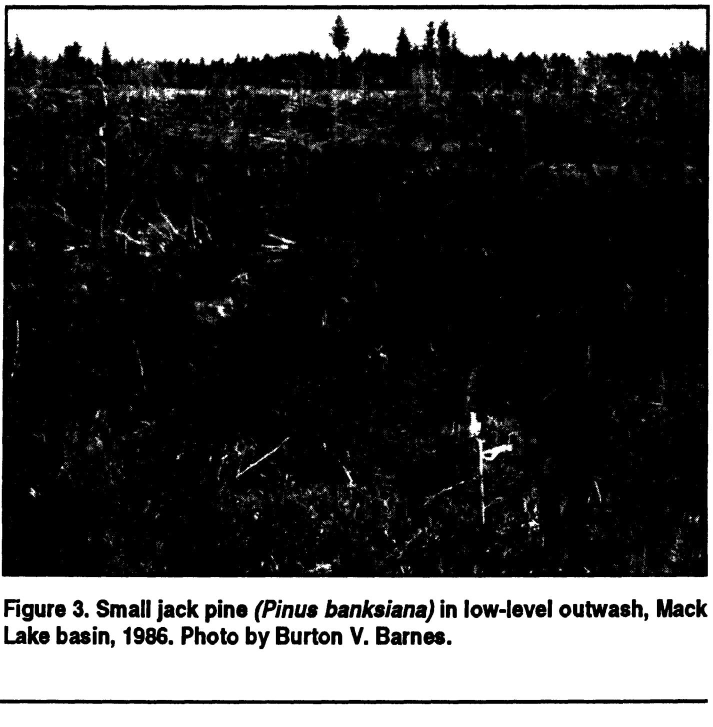


Figure 3. Small jack pine *(Pinus banksiana)* in low-level outwash, Mack Lake basin, 1986. Photo by Burton V. Barnes.

Providing an Ecological Framework

The landscape ecosystem approach applied in the Mack Lake basin indicates that the pattern of warbler occurrence in space, and time as well, is grounded in the basic glacial geology and physiography of the landscape which in turn affects microclimate, soil moisture and nutrient status, the growth and patchiness of jack pine and oak, and the composition and density of ground-cover vegetation.

The approach provides the understanding of whole landscapes such that the best areas for warbler management (by prescribed burning or planting) could be selected to maintain a high warbler population. Landscapes of different and adjacent physiographic features could be selected to maintain the warblers in a given area for the longest possible time, thereby concentrating the management efforts and reducing costs.

The landscape ecosystem approach also provides the ecological framework for detailed studies of warbler nesting relations, reproductive behavior, foraging, and population dynamics. Experience with the warbler showed that it is not just the biology of the species that is important, but more fundamentally understanding whole systems of which the warbler is an integral part.

In summary, understanding earth-surface ecosystems provides an ecological framework and common ground for all resource users. The ecosystem approach is a new way of sensing the world; we shift our focus from species to spaces. Rowe (1992) sums it up this way:

"The primary concern becomes maintenance of landscapes and waterscapes *as complete ecosystems*, because the only way to assure the sustained yields of forests, wildlife and water, now and in the future, is to keep them and all their parts in a healthy state. This is the essence of the *ecosystem approach*. It means that everyone attends to the conservation and sustainability of ecosystems, instead of sharply focusing on the productivity of individual or competing resources—which has been our traditional mode of operation."

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Use Of Landscape Ecosystems for Species Inventory and Conservation

by

Dennis A. Albert

In 1986, as *Regional Landscape Ecosystems of Michigan* (Albert et al. 1986, see Box pages 21-22) was being published by the School of Natural Resources of the University of Michigan, I began working at my present position as the Community Ecologist for the Michigan Natural Features Inventory (MNFI). In my new employment, I immediately began attempting to evaluate the usefulness of our Landscape Ecosystem classification (see article by Burton Barnes in this issue, pages 13-19) and map for the evaluation and inventory of plant communities and also for inventory of threatened and endangered plants and animals. In this article, I will discuss the results of this investigation, including the advantages of using an ecosystem approach over a species-oriented approach for inventory and management of threatened and endangered species, and the potential for expanding such an approach to several states to coordinate research and protection efforts.

The distributions of many of Michigan's plant communities and rare plants are strongly associated with the abiotic factors that were used to define the landscape ecosystems of Michigan. This is reflected in their preferential occurrence in one or a few of the Landscape Ecosystem mapping units. In contrast, if rare species were not responding to these abiotic factors, we would expect a much more random distribution. For animals, strong associations are limited to certain taxonomic groups, such as insects, reptiles, and small mammals, but probably do not apply for highly mobile birds and larger mammals.

Which Species Benefit from an Ecosystem Approach?

Because of the relationship between abiotic and biotic factors (see Box page 23), both common and rare species benefit from using an ecosystem approach to land management. Ecosystem management takes into account the processes that characterize an ecosystem, rather than focusing on the individual species. Concentrating on the individual species is often a very expensive and sometimes frustrating procedure. For most rare species there is little information about the original population size or the critical habitat needs of the species. In contrast, we may have much more information about the ecosystems that these species occupy and the changes that have occurred on these ecosystems during the last 100–200 years of European settlement.

For example, detailed information on the original extent of range and the biology of Kirtland's warbler *(Dendroica kirtlandii)* is less than complete, as it was first found on its breeding grounds in 1903 (MDNR 1992), after intensive logging had already been conducted throughout the bird's known breeding range. However, we have considerable information about the ecosystem that Kirtland's warbler occupies from the General Land Office (GLO) notes, studies of glacial landforms (Farrand 1982), and several county soil surveys. The GLO notes provide us with significant information about the vegetation where Kirtland's warblers nest, including the extent of jack pine *(Pinus banksiana),* the approximate areas and densities of jack pine barrens, the diameters of jack pine encountered, and rough percentages of the forest that were burned (due to logging and settlement) at the time of the surveys.

Similar information exists for rare oak savannas or oak-pine savannas, where the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*) and several other rare or endangered species are found. The forest stand conditions recorded in early surveys can be correlated with information from soils and glacial landform maps for much of the state.

The Ecosystem Approach Advantage

Perhaps the most important use for a landscape classification and map is that they provide a framework for studying the biota of the entire state. When viewed as a single, large unit, the complexity of the entire state is overwhelming, but by dividing the state into smaller, relatively uniform subdivisions, it is possible to recognize patterns and relationships in the landscape and its biota. The descriptions of each landscape unit include the characteristic topographic features (landforms), soil, upland and wetland plant communities, and the natural processes, such as fire or flooding, that maintain the plant communities. Rare plants and animals can then be studied within the context of the landscape unit. It is much more efficient to study rare species within such a context, than to study each of our many rare species in isolation.

In a relatively short period of time it is possible to partition a given area (state, county, or more localized political unit) into a relatively small number of landscapes that contain most of the area's biodiversity. It is then possible to begin protecting or managing representative portions of each landscape for its biodiversity. The major landscapes, based on distinct combinations of climate, bedrock, landform, and vegetation, can be identified and roughly described in a few years. In contrast, it requires much more time to adequately inventory the biota of an equivalent area. New flowering plants are still being discovered, and many insect groups are not yet adequately described. By protecting and managing representative

Continued on page 23

The Regional Landscape

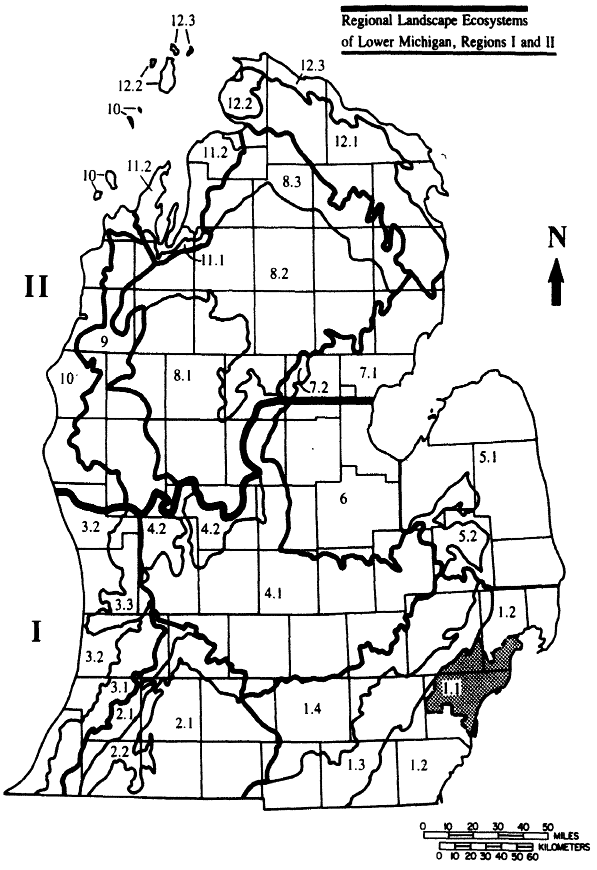
The factors used to delineate regions, districts, and subdistricts include climate, bedrock geology, physiography (glacial land forms), and soil. Macroclimate and bedrock geology are typically important factors for delineating regions, climate and physiography are factors often used to delineate districts, and more localized physiographic and soil characteristics are the basis for subdistrict delineation. Vegetative data (existing vegetation and surveyors' notes of presettlement vegetation), together with topographic and soil data, were used to help develop the map and verify and revise ecosystem boundaries.

Since the hierarchy is not rigid, different factors can be recognized as important for the delineation of mapping units in different parts of the state. For example, the High Plains, District 8, is a sandy high plateau whose subdivisions are based on landform differences; Subdistricts 8.1 and 8.3 are areas of moraine, while Subdistrict 8.2 is an outwash plain. In contrast, District 13, a lakeplain, is divided into subdistricts on the basis of soil texture; Subdistricts 13.1 and 13.3 are sandy lakeplain with areas of limestone bedrock, and 13.2 is clay lakeplain.

In studying the distribution of rare plants within the districts and

Regional Landscape Ecosystems of Lower Michigan, Regions I and II.

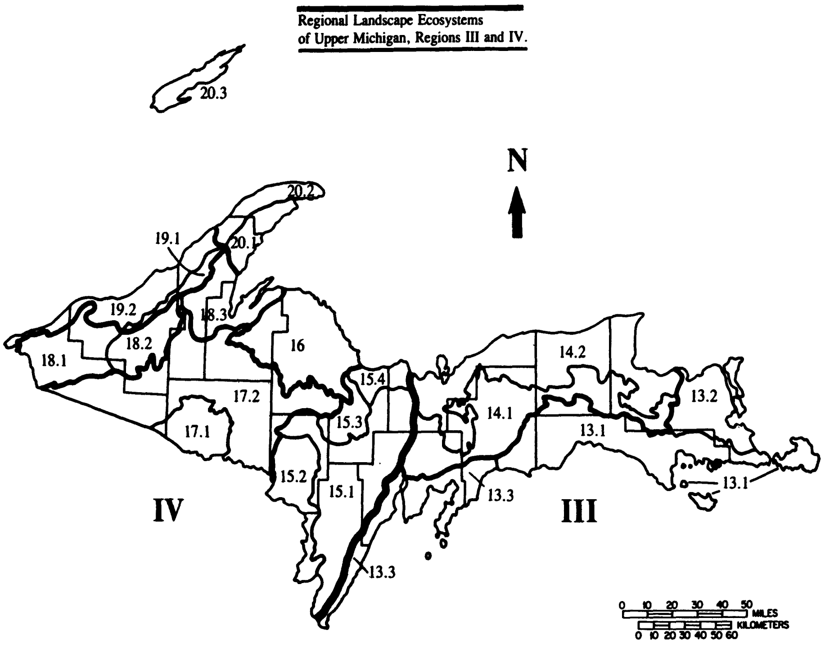
No.	District	Subdistrict	Site Condition	Area Sq Mi (km^2)
Region 1: Southern Lower Michigan				
1.1	Washtenaw	Detroit	Heat island	
1.2		Maumee	Lake plain	2300 (5960)
1.3		Ann Arbor	Fine and medium-textured moraine	1635 (4235)
1.4		Jackson	Interlobate: coarse-textured end moraine, outwash, and ice-contact typography	2060 (5335)
2.1	Kalamazoo	Battle Creek	Outwash and ground moraine	2770 (7175)
2.2		Cassopolis	Coarse-textured and end moraine and ice-contact terrain	720 (1865)
3.1	Allegan	Berrien Springs	End and ground moraine	760 (1970)
3.2		Benton Harbor	Lake plain	1355 (3510)
3.3		Jamestown	Fine-textured end and ground moraine	490 (1270)
4.1	Ionia	Lansing	Medium-textured ground moraine	4810 (12460)
4.2		Greenville	Coarse-textured end and ground moraine	760 (1970)
5.1	Huron	Sandusky	Lake plain	3210 (8319)
5.2		Lum	Medium and coarse-textured end-moraine ridges and outwash	480 (1245)
6.1	Saginaw		Lake plain	2390 (6190)
Region II: Northern Lower Michigan				
7.1	Arenac	Standish	Lake plain	1295 (3355)
7.2		Wiggins Lake	Fine-textured end and ground moraine	110 (285)
8.1	Highplains	Cadillac	Coarse-textured end moraine	2860 (7405)
8.2		Grayling	Outwash	4085 (10580)
8.3		Vanderbilt	Steep end- and ground-moraine ridges	1505 (3900)
9	Newaygo		Outwash	1920 (4975)
10	Manistee		End moraine and sand lake plain	1480 (3835)
11.1	Leelanau	Williamsburg	Coarse-textured end-moraine ridges	100 (260)
11.2		Traverse City	Coarse-textured drumlin fields on ground moraine	750 (1940)
12.1	Presque Isle	Onaway	Drumlin fields on coarse-textured ground moraine	1845 (4780)
12.2		Stutsmanville	Steep sand ridges	270 (700)
12.3		Cheboygan	Lake plain	835 (2165)


Regional Landscape Ecosystems of Lower Michigan, Regions I and II

subdistricts of Region I, it was found that 38% are concentrated in single districts and 24% are concentrated in single subdistricts. Several plants are concentrated in 2 or 3 ecologically similar districts or subdistricts. For example, there are several plants that are common on the near-shore portions of the southern lake plains, including those of Subdistricts 1.2, 3.2, 5.1, and 6.0. Subdistricts 1.4 and 2.1, both rich in prairie fens, an herbaceous wetland type, also share several rare species.

Of the 59 plant communities described by Michigan Natural Features Inventory (1986) for the state, 75% are either found only in one or two neighboring subdistricts, or are found with distinct variants in several districts and subdistricts. In the second case, these differences are justification for re-evaluation and possibly eventual subdivision of a single plant community into several subtypes. An example of this is the northern hardwood forest of Subdistricts 17.1 and 17.2. On the mesic loess-capped ground moraine of Subdistrict 17.2, this plant community includes abundant numbers of several groundcover plants, such as wild leek *(Allium tricoccum)*, Canada violet *(Viola canadensis)*, and blue cohosh *(Caulophyllum thalictroides)*, that are much less common on the sandy loam soils of Subdistrict 17.1. White ash *(Fraxinus americana)* and American elm *(Ulmus americana)* are also much more common overstory trees in Subdistrict 17.2.

The remaining 25% of the plant communities are widely distributed upland forest types or wetland types that have not been sufficiently studied to determine if there are regional variations caused by differences in climate, landform, or soil. Based on past experience, we expect that many of these plant communities will also have considerable biotic differences in different districts and subdistricts.



Regional Landscape Ecosystems of Upper Michigan, Regions III and IV.

No.	District	Subdistrict	Site Condition	Area Sq Mi (km^2)
Region III: Eastern Upper Michigan				
13.1	Mackinac	St. Ignace	Limestone bedrock and sand lake plain	1580 (4090)
13.2		Rudyard	Clay lake plain	600 (1555)
13.3		Escanaba	Limestone bedrock and sand lake plain	780 (2020)
14.1	Luce	Seney	Poorly drained sand lake plain	1515 (3925)
14.2		Grand Marais	Sandy end moraine, shoreline, and outwash plains	1905 (4935)
Region IV: Western Upper Michigan				
15.1	Dickinson	Hermansville	Drumlins and ground moraine	1855 (4805)
15.2		Norway	Granitic bedrock and end moraine	595 (1540)
15.3		Gwinn	Poorly drained sandy outwash	265 (685)
15.4		Deerton	Sandstone bedrock and high, sandy ridges	225 (580)
16	Michigamme		Granitic bedrock	1160 (3005)
17.1	Iron	Iron River	Drumlinized ground moraine	465 (1205)
17.2		Crystal Falls	Kettle-kame topography, outwash, and sandy ground moraine	2390 (6190)
18.1	Bergland	Bessemer	Large, high, coarse-textured ridges and metamorphic bedrock knobs	745 (1930)
18.2		Ewen	Dissected clay lake plain	450 (1165)
18.3		Baraga	Broad ridges of coarse-textured rocky till	575 (1490)
19.1	Ontonagon	Rockland	Narrow, steep bedrock ridge	135 (350)
19.2		White Pine	Clay lake plain	655 (1695)
20.1	Keweenaw	Gay	Coarse-textured broad ridges and swamps	275 (710)
20.2		Calumet	High igneous and sedimentary bedrock ridges and knobs	285 (740)
20.3		Isle Royale	Island of igneous bedrock ridges and swamps	230 (595)

Continued from page 20

ecosystems, we can maintain habitat for as yet undescribed or inadequately inventoried species.

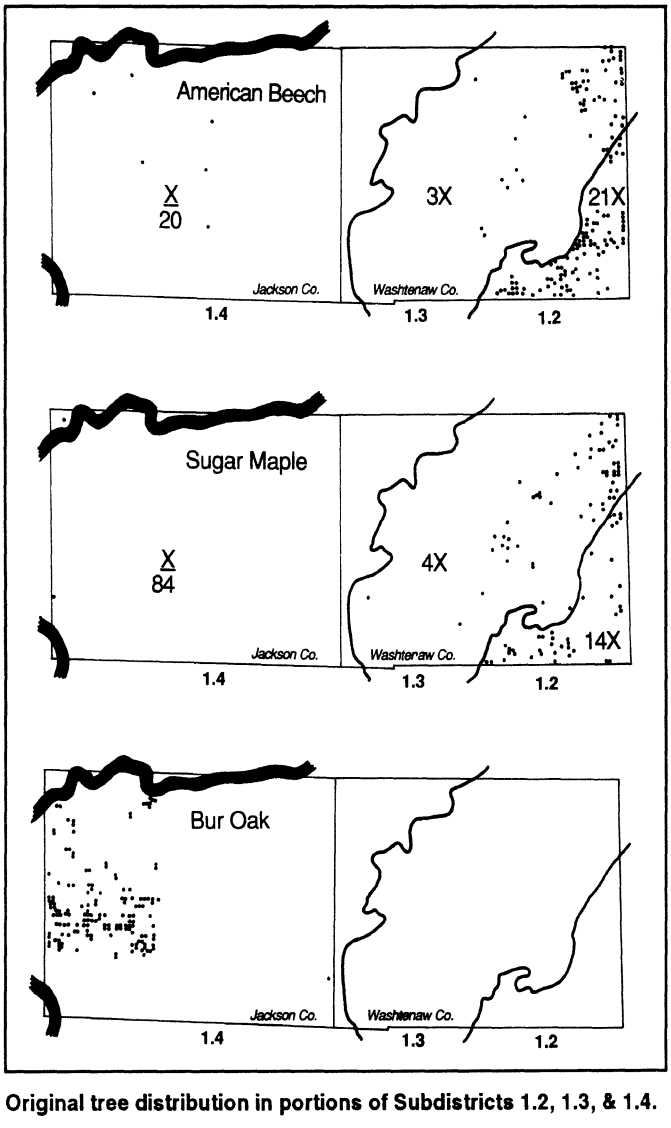
Single Rare Species Management Can Harm Other Species

In the past, rather than managing an ecosystem for the full range of species present, we have often concentrated on the requirements of single species. Such is the case for Kirtland's warbler, a federally endangered bird that breeds only on the jack pine plains of Subdistrict 8.1 in Lower Michigan (see Box page 21). Jack pine is harvested and replanted in plantations to maintain adequate jack pine in the 8–20 year age class for warbler nesting sites (MDNR 1992). Jack pine has been regenerated by planting in plowed furrows, rather than allowing natural regeneration following fire. Plowing has resulted in the destruction of habitat for another rare plant species, pale agoseris (*Agoseris glauca*), and may also reduce populations of other rare biota of the jack pine plains. Minor management modifications could probably benefit pale agoseris without harming Kirtland's warbler reproduction, as pale agoseris is concentrated in small frost pockets, which are not prime habitat for Kirtland's warbler.

Ecosystem Study Provides Insights

To adequately describe a landscape ecosystem, we must study its physical characteristics as well as its biota. In highly manipulated landscapes we have been forced to use historic documents, such as the GLO notes, to reconstruct the original vegetation. This has provided insights into natural disturbance regimes, vegetation patchiness, forest composition, and biotic/abiotic relationships that have proved invaluable for developing restoration and management strategies for ecosystems and their biota. For example, in studying Great Lakes

Species Distributions Correspond to Regional Landscape Ecosystems



Original tree distribution in portions of Subdistricts 1.2, 1.3, & 1.4.

Many of the best documented examples of the strong association between specific landscape ecosystem mapping units and plants or plant communities are for our common forest tree species and forest types. This is demonstrated in the original General Land Office (GLO) surveys of Washtenaw and Jackson counties, Michigan, which include portions of Subdistricts 1.2, 1.3, and 1.4. (See Figure).

The total number of stems for the three tree species being compared, American beech *(Fagus grandifolia)*, sugar maple *(Acer saccharum)*, and bur oak *(Quercus macrocarpa)*, were recorded along the section lines of the two counties. The flat, clay lake plain of Subdistrict 1.2, characterized by nutrient rich, well drained and somewhat poorly drained soils, contains 21 times the expected number of beech (expected number is based on the area of each district included in the 2 county study area), 14 times the expected number of sugar maple, and no bur oak. Both beech and sugar maple thrive on the mesic conditions of the lake plain.

In Subdistrict 1.3, characterized by well drained, loamy soils on rolling topography, there are 3 times the expected number of American beech, 4 times the expected sugar maple, and no bur oak. Conditions are locally well suited to beech and sugar maple, and fires were not frequent enough for bur oak to be common.

In Subdistrict 1.4, characterized by dry to dry-mesic sandy ridges, there were only 1/20 the expected number of American beech, and 1/84 the expected number of sugar maple. All of the bur oak noted in the two counties occurred in this subdistrict. Bur oak was best adapted to the fire-prone, sandy soils, whereas neither beech nor sugar maple were tolerant of these conditions. Studies have demonstrated similar relationships for tree species in neighboring districts and subdistricts throughout the state.

shorelines of Saginaw Bay (Lake Huron), where almost no original vegetation remains due to extensive agricultural development, we found early documentation of Great Lakes water level fluctuation, and the impact of this fluctuation upon the vegetation. Zones of wet prairie and marsh three to five miles wide were maintained by the water level fluctuations. Knowing that water level fluctuation maintained wet prairies, and several rare plants found in these prairies, has shaped management and restoration recommendations.

Studying the physical characteristics of an ecosystem also leads us to investigate similar, unexplored areas of the state to locate a species or several associated species. For example, several threatened and endangered species were encountered during surveys of prairie areas on the lake plain along Lake St. Clair, including three-awned grass (*Aristida longispica*) and seedbox (*Ludwigia alternifolia*). Similar sandy lake plain exists along Lake Erie and Lake Huron. Based on the similarities of the landscape features and soils, surveys were then conducted on the Lake Erie and Lake Huron plains, resulting in the location of several new populations of these and other associated rare plants.

Investigation of physically similar landscapes has resulted in the location of several new coastal plain marshes (wetlands rich in disjunct plant species from the Atlantic Coastal Plain) and northern fens. The approach used for such landscape surveys is to first determine likely areas for a certain plant community or plant on the basis of landform features or soil characteristics, and then use aerial photos and soil surveys to search for similar vegetation "signatures" (e.g., color, tone and texture).

Upland and Wetland Landscapes

For many species, both upland and wetland components of an ecosystem must be intact for long-term viability. This is already recognized for amphibians and reptiles, but it may also be important for many insects, plant species, and even entire plant communities. For example, there are several wetland plant communities characterized by fluctuating water tables. During high water periods, adjacent low uplands may serve as temporary habitat for plants occupying the edges of these wetlands. By thinking in terms of ecosystems, we are more likely to include some uplands in the management plans for such wetlands. Michigan has numerous past examples of wetland acquisition which did not include adequate upland buffer.

Prairie fen, a wetland plant community occurring at the base of calcareous, gravelly kames or end moraine ridges, is dependent upon adjacent uplands for calcareous ground water and possibly for seasonal fires. It has been documented that the ridges burned regularly prior to and shortly following European settlement, both as the result of Native American and lightning-caused fires (Chapman 1984). This may have been responsible for the persistence of prairie plants within the wetlands. A combination of fire suppression and alteration of water quality and chemistry have resulted in fen degradation.

Land Use Patterns

Human land use has always been largely determined by characteristics of the landscape. As Michigan was being settled, agricultural development was concentrated on fertile, well drained moraine ridges, and then moved to the fertile, wet lake plains as these were drained. Our continued development of the state has changed, but is still largely predictable, as is the long-term impact of this development upon certain biota. J. S. Rowe (1990) has pointed out that most threatened species are actually the result of destroying ecosystems and their native biota through systematic alteration for agriculture or other human use.

Our intensively managed landscapes are the ones most urgently requiring biotic inventories, which must then be followed by ecosystem restoration. For successful maintenance of native plant communities and their included biota, restoration based on an understanding of ecosystem processes is typically required. In Michigan, many of our rarest plant communities are rare because of intensive agricultural development within certain landscape ecosystems. These plant communities include tallgrass prairie, wet prairie, oak savanna, and mesic southern forest.

How Inventories Benefit

We are using *Regional Landscape Ecosystems of Michigan* and other thematic maps (soils, glacial landforms, or bedrock outcrops) as predictive tools for inventories of plant communities and single species. Such inventories can be made more efficient by knowing where a plant community or species is most likely to occur. This approach emphasizes the predictability of many of Michigan's threatened and endangered species, rather than assuming that most rare plants are randomly located.

In our surveys of prairie fens, an herbaceous wetland type of southern Lower Michigan, we found that 88% were in Subdistricts 1.4 and 2.1. (See box pages 21-22 for subdistricts.) Any future comprehensive survey of fens would begin in these two subdistricts. Comparison of fens in different subdistricts has demonstrated that there are major differences between fens in different districts or subdistricts. Those of Subdistrict 2.1 are rich in plants characteristic of the tallgrass prairie, whereas those of 1.4 contain few of these plants, but contain more northern calciphiles typically found along the northern Great Lakes shoreline. The few fens found outside of these two subdistricts tend to be much less species-rich.

A landscape approach can also be useful for faunal surveys. For example, known populations of Karner blue butterfly, a federally listed endangered species, are concentrated in two areas of sandy lake plain and outwash plain, both of which originally supported savannas or open forests of white oak and white pine. Major rivers had downcut through both sand plains near the Karner blue localities. Inventories in 1992 on two similar large outwash plains along large rivers resulted in the discovery of several more populations of the butterfly.

Expanding to Several States

The geologic formations, geomorphological features, and soil series that determine the distribution of biota can easily be mapped across state boundaries. Knowing the extent of these features in an adjacent state or states can be important for allocation of a state's acquisition, management, and research resources. A project is presently underway to map and classify the regional landscape ecosystems of Minnesota, Michigan, and Wisconsin.

Several of Michigan's plant communities and threatened or endangered species are shared by adjacent states. These include dwarf lake iris (*Iris lacustris*) and Pitcher's thistle (*Cirsium pitcheri*), both federally endangered species and Great Lakes endemics, and also coastal plain marshes, lake plain prairies, oak openings, and prairie fens, all rare plant communities rich in rare plants and animals. Knowing the full extent of potential habitat, whether it has been adequately explored or not, is necessary to adequately evaluate the threat to a species or plant community.

Further Refinement of the Landscape Approach

Wetland and aquatic systems. Much of our original landscape research was based on data from upland forests. Further work has demonstrated that the same landscape ecosystem boundaries adequately encompass and describe herbaceous uplands and herbaceous and forested wetlands.

Usefulness of the landscape ecosystem approach for aquatic systems has not been fully investigated. Basin morphology and water chemistry for both streams and lakes are at least partially determined by glacial landform and substrate, factors that are equally important for upland biota. For the streams and lakes that we have studied, glacial landform and substrate have proved useful for understanding the flora and fauna and for developing management recommendations. For example, rivers on the sand lake plain of the eastern Upper Peninsula of Michigan in Subdistrict 13.1 (see Box page 22) differ greatly from those of the clay lake plain in Subdistrict 13.2. The rivers on the sand lake plain have broad flood plains, numerous meander loops, and sandy bottoms. In contrast, those of the clay lake plain are narrow, steep banked streams with narrow flood plains, relatively straight channels, and no meander loops.

Another intensive study of over 90 Great Lakes coastal wetlands (Michigan Natural Features Inventory 1987, 1988, 1989) indicates that there are major floristic differences caused by climate (latitudinal differences), substrate, and geomorphological characteristics of the shoreline. The coastal marshes of several districts and subdistricts differ greatly in floristic composition.

Local mapping units. *Regional Landscape Ecosystems of Michigan* contains no map units smaller than the subdistrict. Further subdivisions are typically identifiable within a district or subdistrict and may be more precisely correlated with a specific plant association or rare species. For example, the lake plain of southeast Michigan (Subdistrict 1.2) can be further divided into clay lake plain, sand lake plain, and a narrow zone along Lake Erie and Lake St. Clair that is influenced by the direct water level fluctuations of these lakes. Each portion of the lake plain originally supported different vegetation. Mesic deciduous forest grew on the clay plain, oak savannas and wet prairies grew on the sand plain, and swamp forests and extensive marshes grew near the shorelines of Lake Erie and Lake St. Clair.

Ultimate management decisions and manipulations are made at this local level. Since state-wide ecosystem classifications do not generally delineate units at the local scale, it is important that the concepts of ecosystem management become part of the training for local managers. The information within the larger state-wide framework must be refined to maximize usefulness by the local manager. This may be best done by providing examples of how the regional classification can be expanded for local management.

Conclusion

Regional Landscape Ecosystems of Michigan is a hierarchical, multifactor approach to land management. The approach provides a state-wide framework for inventory, study, and management of plant communities and their included rare biota, by delimiting the distribution of ecosystems within which the plant communities occur.

Although we have traditionally managed individual rare species rather than ecosystems, this is often a less than satisfactory approach. Concentrating on the physical and spatial characteristics of ecosystems allows for more efficient inventory and more effective management that can benefit the entire biota of an ecosystem, including the rare species.

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Practical Ecosystem Management For Plants and Animals

by

Sylvia Taylor

By now we should all understand that everything is connected to everything else and planet Earth is a single ecosystem. Managing the well being of the earth as a whole is extremely complex. Global considerations are just beginning to affect management decisions only because actions resulting in ozone depletion or nuclear war are such obvious threats to the system.

Human society is territorial as is evidenced by national frontiers, state and township lines, public park and forest boundaries and backyard fences. It would take a "second coming" to reform human turfism. Everyday management decisions within our various "turfs" add up to regional and global effects; but our control usually ends at the fence line.

On a broad scale, an ecosystem approach to species or biotic community conservation is simply looking beyond the fence and looking beyond the management disciplines in which we work. On a fine scale, good ecosystem management is working intelligently with the environmental variables we can manipulate while understanding the impacts of our actions.

When using an ecosystem approach for species conservation it is important to have answers to a few simple questions:

(1) Is an ecosystem approach new to species conservation?

(2) Is the approach different for plants vs. animals?

(3) Are all species equal?

(4) Is there fundamental agreement on sensible ecosystem management?

Answering questions like these may require involved thinking, yet the answers are all a simple "no." My experience in public service tells me that some of those anxious to launch into a new enlightened era of conservation will, nevertheless, subject us to a confusing array of "yes" answers to the same questions. This article looks at these questions one at a time in an attempt to focus our attention on the main pair of questions at hand:

Will future managers look at and understand more ecosystem variables before making management decisions? How will they accomplish this? Recovery efforts for the Kirtland's warbler will be used as an example of how our thinking and approaches are evolving.

Ecosystem Approach to Species Conservation–Is it New?

Humankind has been managing ecosystems since the dawn of history. Too often it has been species mismanagement because of ignorance, short term objectives and individual greed. Sometimes it has been a creative force for species, providing vast wild grasslands or small beautiful gardens.

The two volume international symposium, *Man's Role in Changing the Face of the Earth* (Thomas 1956), presented a comprehensive historical look at change in the ecosystem of which man is a part. It has had a far reaching influence in the 37 years since its publication. Great works such as these have broadened our concern for the earth's ecosystem. Conservationists have long appealed for a more holistic approach to management of the individual fragments of that larger system.

Natural resource managers have usually worked with specific missions for specific species enhancement and addressed ecosystem factors of primary importance to accomplishing their missions. Ecosystem management for a specific species inevitably enters a game of winners and losers.

Back in the late 1970s a frustrated endangered species biologist from Wisconsin told a regional meeting, "I don't know what to do with our fish biologists. They kill off everything in the stream; then put back what they want." Waterfowl biologists have been better. They manage wetlands for ducks and proudly point to a host of other wetland species that benefit. But there are other losers. Things become intense when high profile species management missions enter the same ecosystems. In Michigan, the Deer Range Improvement and Forest Regeneration programs have been the basis for lively planning session debates and name calling over whether a particular tract would become a "mishmash of low value trees and shrubs" (good deer range) or a "biological desert" (densely stocked red pine plantation).

State and national forest plans attempt to bring species ecosystem management into peaceful equilibrium. A recent draft of Michigan's Escanaba River State Forest Comprehensive Resource Management Plan (MDNR 1990) states: "Forests are complex ecosystems composed of highly interactive biotic and abiotic components and containing resources that include plant, animal, and microbial species, air, water, soil, and deposits of rock, minerals, and petroleum. To assure proper management of the state forests for the public good, it is the declared policy of the Michigan Department of Natural Resources to manage the state forests to yield that combination of products and services which best meets the physical, psychological, and spiritual needs of all

...Management for a specific species inevitably enters a game of winners and losers

Karner blue butterfly *(Lycaeides melissa samuelis)* perched on an infloresence of wild lupine *(Lupinus perennis)*. Photo by Ann B. Swengel.

people now and in the future."

That is quite an ambitious policy for ecosystem management! It also reminds us that ecosystems will be managed for those species that "people" (the public) want. No, an ecosystem approach to species conservation is not new. Yes, future managers will look at and understand more ecosystem variables when making management decisions. How will they accomplish this?

Different Approach for Plants vs. Animals?

Some would quickly say that plants are tied to the land while animals move around, so ecosystem management would have differences for plants vs. animals. This attitude is reflected in North American game laws which claim animals as common property while plants go with the land. There are, therefore, some legal differences in how we may approach ecosystem management for plants or animals. In Michigan, only endangered or threatened plant species are claimed as common botanical resources through their protection under the state Endangered Species Act. There is also some lesser protection on public land under the "Christmas Greens" act. In time, legal protection for plants may go further depending on public desires.

In reality, plants are no more tied to the land than animals. A seed is a complete plant. If ingested by a mammal it has legs; if by a bird, it has wings. Plants also use wind and water dispersal, clonal spread, insect pollination and numerous other effective ways to put a given genotype into a favorable habitat. The unwanted spread of exotic species painfully illustrates the subtle mobility of plants.

Animals may be more tied to particular limited habitats than their associated plants. For example, the perennial wild lupine *(Lupinus perennis)* of Midwestern native grasslands may occupy a variety of sandy, disturbed habitats. A single flower head can catapult seeds over a 100-foot diameter area. It is host to an endangered animal, the Karner blue butterfly *(Lycaeides melissa samuelis)* whose larvae feed upon it. The butterfly cannot exist without the lupine; a plant-animal relationship in which the animal has a tighter land-based requirement than the plant.

In addition to specific habitat requirements there are also many examples of territorial behavior restricting animal movement to very small land areas. Forest fragmentation is harmful for some plants and some animals while benefiting other plants and animals.

My personal view of comparing the management of plants and animals is similar to comparing men and women. There are usually some obvious differences. When it comes to employment, the job description must be the same. Plants and animals have most of the same problems making a living in their various habitats. Plants, however, often visually define biotic communities and management boundaries, so they are more easily addressed in management plans. No, ecosystem approaches are not fundamentally different for plants vs. animals. Yes, future managers will look at and understand more ecosystem variables when making management decisions. How will they accomplish this?

Are All Species Equal?

Sometimes we forget that equal means "the same" or "identical." Species are defined by their differences. The question relates to the idea that all species might be of equal importance to the web of life; that if we fully understood ecosystem functions, their equal importance would be evident.

It certainly is true that we fail to appreciate the importance of many species. Diatoms, for example, make up a significant percentage of the earth's biomass and contribute greatly to our oxygen supply. Are there any endangered diatom species we should try to recover? The importance of individual diatom species is probably a function of time. Those adapted to a previous set of global conditions would have scientific value but be of less true importance than species that will flourish under projected global warming. If all species were of equal importance, evolution would be unnecessary.

Threats to species are unequal. Human activity causes extinctions much faster than evolutionary compensation.

We, therefore, put a higher value on species we threaten. Some species are of great current economic value. We certainly can not afford to endanger corn or rice. If these were threatened, we would have to value these crop plants over wolves or eagles. Our problem is that we do not understand the true relative importance of various species so we are afraid to assign any a low value. No, all species are not equal. Yes, future managers will look at more ecosystem variables when making management decisions. How will they accomplish this?

Sensible Ecosystem Management

Presently the term "ecosystem management" has popular appeal among scientists and the general public. It sounds like we are finally looking beyond ecosystem parts and individual interests. We aren't all looking at the same horizon. Scientists form hypotheses about ecosystem functions according to a broad range of training, experience and professional interactions. They constantly challenge each other's ideas and conclusions. We will surely continue to receive contradictory management advice from scientists. A hotel owner adjacent to a National Forest may applaud USDA Forest Service plans for ecosystem management while mentally excluding his own property from the system. A county drain commissioner may have similar ecosystem objectives to those of the local farm bureau but different from those of a national organization such as Ducks Unlimited.

Ecosystem management will not free us from the same hard decisions we have always faced formulating management objectives. The formulation of management objectives will become increasingly difficult as we draw ecosystem lines across each other's turf.

The report "Michigan's Environment at Risk" (Rustem et al. 1992) approaches the problem of broad agreement on management objectives by examination of "relative risk." Of four risk categories, the first listed in the highest category is "Absence of land use planning that considers resources and integrity of ecosystems."

All 24 factors listed in the four categories are ecosystem risks. Solutions are suggested in the realm of public policy and research. But the advice of practical resource managers with strong scientific training is the key to selecting the right questions for mission oriented researchers to answer. Practical resource managers are the people to whom policy makers will come when they want to know what works and how much it will cost. No, there is no fundamental agreement on sensible ecosystem management. Yes, future managers will look at and understand more ecosystem variables when making management decision. How will they accomplish this?

Kirtland's Warbler Recovery Efforts: Evolution of an Ecosystem Approach to Management

Lower Michigan's pre-settlement landscape included thousands of acres of sandy jack pine-northern pin oak *(Pinus banksiana-Quercus ellipsoidalis)* dominated forest and blueberry *(Vaccinium)* barrens. Periodic wildfires drove a cyclic pattern of plant and animals succession in which members of the biotic community were particularly adapted to exploit the dynamics of the burns. One of these species was the Kirtland's warbler *(Dendroica kirtlandii).* Between about 6–20 years after a fire it would nest in a savanna-like setting among young jack pine and sprouts of northern pin oak.

The Kirtland's warbler was first discovered on its wintering grounds in the Bahamas in 1879. Its Michigan nesting grounds were discovered in a young jack pine stand in Oscoda County in 1903. Nesting pairs have never been observed outside the Lower Michigan jack pine ecosystem.

Early statewide conservation efforts for the area emphasized reforestation with fire control to bring trees to merchantable size as timber. By the late 1950s it was clear to some that these practices had greatly reduced nesting habitats for the Kirtland's warbler. Four special management units were set up to

Kirtland's warbler *(Dendroica kirtlandii)* perched on jack pine *(Pinus banksiana).* Photo by Lou George, USFWS.

try to simulate pre-settlement habitat. By the time the effectiveness of the special management was demonstrated, the majority of other habitat had passed the successional stage usable by the species. By 1974 the warbler population dropped to its all time low of 167 singing males; about half on the management units.

With passage of the federal Endangered Species Act, the fate of the Kirtland's warbler took on a status warranting a review of habitat management in the entire jack pine region. A large percentage of potential Kirtland's warbler habitat was under state and federal forest management; the poor economic productivity of the lands having discouraged private ownership. It was determined that the species could be recovered entirely on public lands by a harvest of jack pine every 50 years (i.e., 50-year commercial rotation).

In the late 1970s, 134,000 acres of jack pine and Kirtland's warbler habitat in 24 management areas were designated for joint management: birds and timber. Between 36,000–40,000 acres of productive nesting habitat supporting 1,000 singing males would be available at all times. An annual supply of 50-year old jack pine timber would be available on 3,600–4,000 acres. The endangered species program paid for tree planting; other funds paid for forest management.

Management units were considered multiple use land areas under a "Key Value" system. The first key value was assigned to Kirtland's warbler and the second to timber. Other management objectives included public recreation uses, particularly hunting of white-tail deer and snowshoe hare. If a lesser objective was compatible with a higher key value, it was allowed. Snowmobiles were compatible. Trail bikes were not. Active nesting habitat carried more restrictions than management areas currently in other stages of the rotation. Existing conflicting land uses of oil and gas extraction and military training were successfully addressed but only because of the power of the federal Endangered Species Act.

Like many new operations, things did not go according to schedule. At first only about half the planned habitat was regenerated. In 1980, a 23,000-acre wildfire, the Mack Lake Burn, made up the difference for awhile by naturally regenerating the jack pine, as fire maximizes the release of seeds from the cones and prepares the seed bed. This fire did much more than bail out a struggling recovery program. It provided an opportunity for ecosystem analysis of a broad, burned over landscape.

Initially there was no planned integrated effort. Several independently conceived study projects came together within the forum of the Kirtland's Warbler Recovery Team's semiannual open meetings. With only six years from burn to Kirtland's warbler occupation, managers and forest ecologists mapped soils and jack pine stocking and classified ecosystem units. Their work overlapped with ornithologists who studied establishment, occupation and territorial use by the warbler. Communication among scientists and semiannual reports to the recovery team greatly broadened everyone's understanding of the system. These understandings continue to help formulate improved management techniques.

In 1990, another wildfire in Crawford County swept through a large red and jack pine plantation within a Kirtland's warbler unit. The killed trees were only five years from rotation and still quite valuable for timber harvest. Wildlife biologists wanted to leave the dead snags, claiming they would help create ideal habitat. Foresters wanted to salvage the value of the logs, claiming soil scarification by logging operations would help create ideal habitat. In order to evaluate outcomes, part was left; part was harvested. A recovery team-appointed salvage committee developed scientifically testable guidelines for similar side by side comparisons for any future wildfires. This initiative asks a powerful ecosystem question. Can we maintain the integrity of the system while extracting resources?

The Kirtland's warbler shares its ecosystem with other species in need of the same special management for early successional stages including four plant species listed as "threatened" or "special concern" on the Michigan endangered species list. These now receive more attention within the management plan.

Public support of present management varies. Recently, the Michigan Chapter of Trout Unlimited dedicated a tract of its land adjacent to AuSable River frontage to Kirtland's warbler management. Many neighbors dislike the large clear-cuts which set back succession. After being raised with a reforestation ethic and respect for ancient forests, few view new plantations or young savannas as ideal settings for vacation or retirement. Off road vehicle operators doubt so many restrictions are necessary. On the other hand, people come from all over the world to view the Kirtland's warbler. The Grayling Holiday Inn has joined the ecotourism business by becoming headquarters for tours conducted by the U.S. Fish and Wildlife Service. As time goes by, tour guides have more and more to say about the total ecosystem.

Conclusion

The endangerment of species, like the Kirtland's warbler, has helped us look more closely at the systems we affect. Yes, future managers will look at and understand more ecosystem variables when making management decisions. How will they accomplish this? By combining their training with everyday practical knowledge and experience and applying these to a broader set of conservation values.

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Ecosystem Management in the Forest Service: Linkage to Endangered Species Management

by

Thomas M. Quigley and Stephen E. McDonald

Natural resource management agencies have been given very specific responsibilities with respect to ecosystems and populations of animal and plant life. It is rarely the case that an individual agency or landowner has responsibility to manage an entire ecosystem and its components. One agency may have responsibility to manage the summer habitat of an endangered species, another the winter habitat, and yet another the population level of the species itself. It is easy to see why developing conservation plans and recovery strategies can be so complicated and involved.

Although considerable literature now exists on endangered species management and on management of ecosystems, a major complicating factor is that the management of ecosystems and their components requires cooperation among several ownerships and agencies. In addition, potential recovery of an endangered species, such as the northern spotted owl (*Strix occidentalis caurina*) or the Snake River (chinook) salmon (*Oncorhynchus tshawytscha*), may have economic impacts that exceed a billion dollars. This reinforces the urgent need to find solutions to endangered species management, not only to speed threatened and endangered species recovery, but also to improve resource use predictability. Both biological and economic considerations played a role in the recent USDA Forest Service announcement of adopting an "ecosystem" approach to its management.

What is Ecosystem Management?

Odum (1971) has defined an ecosystem as any unit that includes all the organisms (the biotic community) in a given area interacting with the physical environment (abiotic components) so that a flow of energy leads to trophic structure, biotic diversity, and material cycles. Ecosystems, then, can exist at various scales from a small pond to a complex association of forest and rangeland types.

Managing an ecosystem requires knowledge of the relationships, interdependencies, structures, and functions of its component parts. Also, agencies are assigned responsibilities to manage ecosystems or their components to meet multiple objectives deriving from legislative and executive mandates.

The Forest Service is currently in an evolutionary process of defining exactly what its ecosystem management will become

These "social" objectives must be met through a complex process of scientific, economic, political, and social credibility tests. The question of sustainability is a major component of the discussions concerning social goals. (In this context all goals provided through the political process are social goals whether they be viable population levels of a given species or provision for a given output of timber products).

Maintenance of viable population levels of species and maintenance of resource flows in the long-term require scientifically credible approaches that also have socially acceptable economic and political consequences. Because humans are an integral part of the ecosystems that must be managed, it is evident that science alone cannot determine what ecosystem management is for the USDA Forest Service. The Forest Service is currently in an evolutionary process of defining exactly what its ecosystem management will become. This is a socio-political process with complex technical constraints and ramifications.

Ecosystem Management–Forest Service Style

In a letter dated June 4, 1992, the Chief of the Forest Service announced to Regional Foresters and Station Directors that the Agency would adopt an "ecological approach to management" of the National Forests and Grasslands. He stated that this approach would require managing for a blend of human and environmental values, resulting in diverse, healthy, productive, and sustainable ecosystems.

The Chief's announcement followed three years of concept development through the Agency's "New Perspectives" Program. In April 1992, Jim Overbay, Deputy Chief for National Forest System, USDA Forest Service, delivered a speech at a National Forest Service Workshop in Utah on "Taking an Ecological Approach to Management." This speech, and subsequent conferences and workshops, led to adoption of the principles of ecosystem management for the Forest Service. Each Region and Research Station combination were challenged by the Chief to develop a strategic plan for implementing ecosystem management regionally. Strategic plans for each Forest Service Region have now been proposed. Currently, implementation plans related to these strategic plans are being constructed. The evolutionary process continues.

Principles for Ecosystem Management

Ecosystem management emphasizes entire systems, rather than individual species, components, or products. Relationships and connectivity between biological components at various scales are considered vital to understanding and managing ecosystems. Ecosystem management, as envisioned by the USDA Forest Service, rests on the following six principles (Overbay 1992).

Sustainability. Restore and maintain diversity, health, and productivity of forests and grasslands. Provide commodities and uses consistent with sustained vitality and resiliency of ecological systems.

Dynamics, Complexity, and Options. Ecological systems have a characteristic range of natural variability. Change is fundamental. Scale is important and predicting outcomes is complex and uncertain. Conservative approaches and adaptive management are key to maintaining options and addressing risk for the future.

Desired Future Condition. Integrate ecological, economic, and social considerations into practical, clearly stated, measurable objectives. The desired future condition may change through time, reflecting dynamic ecological systems and public values.

Coordination. Ecosystems ignore administrative, ownership, and jurisdictional boundaries. Cooperation with others and coordination of goals, plans, and analyses is essential, especially at larger scales.

Integrated Data and Tools. Inventories, classifications, mapping efforts, data bases, and analysis methods that cut across traditional functional disciplines are necessary.

Integrated Monitoring and Research. Research and monitoring must be more fully integrated with management in providing a strong scientific basis for management decisions.

Ecosystem management principles and technology have been developing for some time. This conceptual evolution has accelerated since the policy announcement by the Chief in June 1992. Several workshops and conferences have been held to better define what ecosystem management will become for the Forest Service. This dynamic process will accelerate throughout 1993.

Pacific Northwest Strategic Plans

Working from the principles of ecosystem management announced by the Agency in April and June 1992, the Pacific Northwest (PNW) Region and PNW Research Station developed a strategic plan for ecosystem management on National Forests and Grasslands in Oregon and Washington. This plan was intended to clarify concepts and provide a framework for developing actions to implement ecosystem management. It affirms the principles and outlines eight elements. These eight elements each consist of a description of the current situation, a description of the strategy, and a brief list of example actions. The vision for ecosystem management and an outline of the eight elements is provided here, taken from a letter by Lowe and Philpot (1992):

"We recognize our primary responsibility is to provide healthy ecosystems for Americans, present and future, and we assure the vitality, diversity, and sustainability of PNW National Forests and Grasslands while providing multiple benefits. We reflect the Principles of Ecosystem Management in the way we work, in the decisions we make, and in our relationships with other agencies, organizations, and individuals. As a result, we have earned a reputation as skilled stewards of National Forests and Grasslands and enjoy the confidence and support of the citizens."

The ecosystem management strategic plan elements are: (1) Public involvement, communications, and partnerships, (2) Ecosystem characterization, mapping, and analysis, (3) Information management and decision support, (4) Forest Plan implementation, (5) Monitoring, evaluation, and accountability, (6) Research and development, (7) Technology transfer, training, and education, and (8) Organization, program development, and budget.

Other Region/Station combinations have also developed ecosystem management strategic plans. Each will provide their own unique approach to balancing ecological, economic, and social values within a strong science-management framework. Each plan will include a move toward multiple-species management as it relates to threatened and endangered species.

Each plan will include a move toward multiple-species management as it relates to threatened and endangered species

The obvious mandates of the law to provide species-specific plans for endangered species will remain a driving force in planning for those species already listed. The emphasis on the "whole" becomes apparent when one considers the possibility that one endangered animal might depend on consumption of another endangered animal or plant for its survival. Developing integrated plans for these species is required to achieve conservation of the ecosystem as a whole: a complex challenge for the Forest Service and its Federal and state sister agencies.

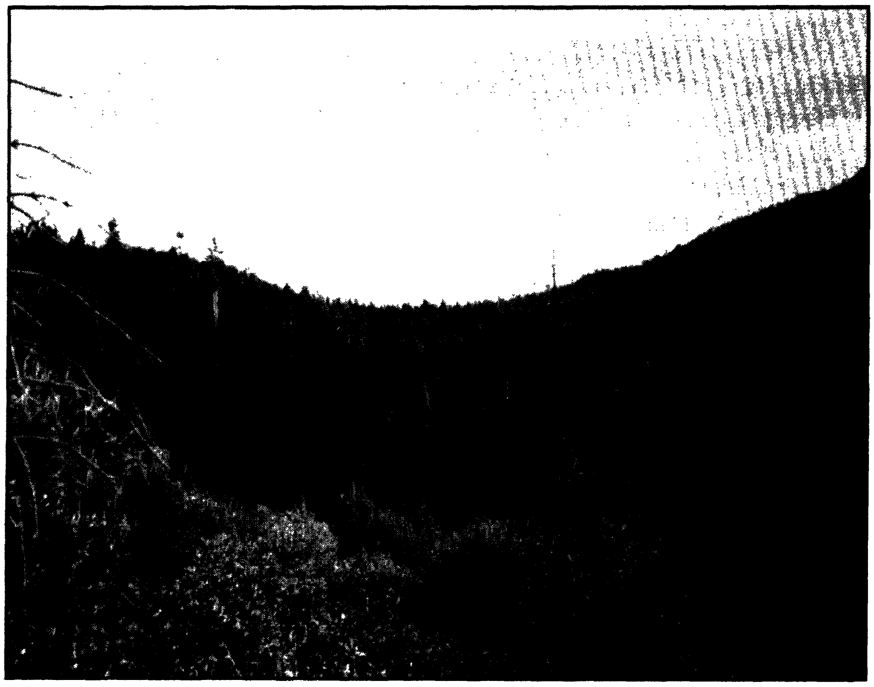
The Blue Mountains Restoration Experience

The Blue Mountains restoration project is an example of ecosystem management being applied within the Forest Service. The forest and rangeland ecosystems of the Blue Mountains of eastern Oregon and Washington are severely stressed (Gast et al. 1991). This is evidenced by epidemic levels of spruce budworm defoliation on over 50% of the forested area (more than 1.2 million hectares), seven years of prolonged drought, declining populations of anadromous fish, large-scale wildfires, and massive tree mortality (Wickman 1992, Quigley 1992). Although these problems are evident on all ownerships within the Blue Mountains, most of the area is federally owned.

An assessment of ecological conditions on Federal land was initiated in the summer of 1992 by the Pacific Northwest Region and the National Forests of the Blue Mountains. This effort used a generalized ecological approach to determination of ecological conditions within major drainage basins (Caraher et al. 1992).

The approach follows closely the "sustaining ecological systems" process being developed by the Northern Region of the Forest Service. The main principle underlying this assessment was: when an ecosystem element or process is pushed beyond its natural range of variability, that element or process, as well as others that depend on it, may not be sustained naturally. In other words, biological diversity and ecological function are at risk.

For this analysis, the Blue Mountains were divided into three broad climatic zones and nineteen river basins. Nine ecosystem elements were selected to serve as indicators of ecosystem health including percentages of successional stages and species associations, density and vigor of lodgepole and ponderosa pine stands, amount of fuel available, and conditions of riparian areas and stream banks.


A portion of the watershed in the Wallowa-Whitman National Forest, Oregon, in the Blue Mountains. Photo by La Grande Ranger District, USDA Forest Service.

The range of natural variability (the conditions that existed prior to organized fire suppression and extensive timber harvest) was estimated for each element. The current condition for each element was estimated after consultation with resource managers from the Blue Mountains area. Five river basins were found to be far outside, five were outside, and nine were close to or within the naturally sustainable ranges of ecosystem health, based on the nine chosen elements.


Snake River (spring chinook) salmon *(Oncorhynchus tshawytscha)*. Photo by La Grande Ranger District, USDA Forest Service.

This analysis led to a more detailed evaluation of activities needed to help restore ecosystem integrity to the Blue Mountains. This evaluation is now concluding. It involved a highly concentrated effort to identify actions that would begin the restoration process over a wide area. The effort has resulted in identifying an integrated set of activities for a three-year program of work ranging from a systematic reintroduction of fire and related monitoring to thinning overstocked stands and/or reforestation. The emphasis is on restoring normal ecosystem functions and processes in stressed range, riparian, and forest ecosystems, not on particular output targets or individual species management objectives.

Restoration activities for the Blue Mountains fit in the matrix of other conservation and recovery efforts for fish and other species of wildlife and plants in the area. For example, these activities are planned to be concurrent and consistent with efforts to develop conservation and recovery plans for Snake River Salmon stocks under the Endangered Species Act. The emphasis is on healthy, productive, and sustainable ecosystems that provide diverse viable populations of plant and animal life. The focus is radically different than simply attempting to determine compatible ways of providing for a given level of commodity production.

The Blue Mountains process was necessarily rushed to meet critically ailing ecosystem needs and deadlines for budget processes. Nationwide, additional National Forest System projects using the ecosystem approach are being developed in a less hurried time frame. As they take shape across all the National Forests they represent the evolutionary process of ecosystem management implementation developing in the Forest Service.

The Blue Mountains Natural Resources Institute in La Grande, Oregon, has actively promoted and facilitated efforts to help restore ecosystems on all ownerships in the Blue Mountains. The Institute is a partnership organization of groups that conducts or is interested in natural resource research, development, application, education, and demonstration.

High on the list of potential problems is the question of jurisdictional boundaries

The Institute has, in cooperation with its partners, undertaken three major activities that address ecosystem health and restoration (USDA 1992). These activities include a synthesis of existing knowledge and methods relating to ecosystem health and restoration, development of a set of studies to address the gaps in knowledge that hinder moving to healthy conditions across all ecosystems in the Blue Mountains, and initiation of a monitoring framework that will address ecosystem health on all ownerships. This cooperative approach on all ownerships represents another step in achieving ecosystem management.

Future Challenges

The management of National Forests and Grasslands is changing in a fundamental way. The shift is not a superficial or cosmetic move into yet another version of functionalism (developing individual resource-specific plans and budgeting them separately). The questions of scale and integration have now become important parts of the discussion; scale not just in terms of spatial aggregation, but also in terms of time and assemblages of species being addressed simultaneously. It represents a retooling of our thoughts beyond what is taken out of the system for consumption and use by humans to include concern for sustaining ecosystem functions, processes, structure, and components. It is a realization that social goals are more than expressions of targets and commodities. It is a realization that there simply cannot be a special plan to address each species by itself, but that integrated, long-term planning and actions are required to achieve ecosystem management objectives.

There are obstacles to achieving true ecosystem management that require attention in the short and long term. High on the list of potential problems is the question of jurisdictional boundaries. Issues such as ownership of data, private landowner's property rights, planning and implementation authorities, divided responsibilities in management authorities, budget accountability within the current functional appropriations process, and lack of understanding of basic relationships pose major challenges to achieving true ecosystem management. Ecosystem management, however, is a requirement for resolution of the natural resource questions that face the nation. We must learn to do it and do it well. Our collective survival is at stake.

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Spotted Owl Protection: Unintentional Evolution Toward Ecosystem Management

by

E. Charles Meslow

What began in the early 1970s as a northern spotted owl (*Strix occidentalis caurina*) research program rapidly evolved into an agency and interagency forest planning effort. Along the way, the issue of spotted owl conservation has drawn increasing public and political attention. Because of the Endangered Species Act (ESA) and the owl's listing as threatened, the northern spotted owl now serves as the surrogate for other old forest associated species and for the old-growth forest ecosystem of the Pacific Northwest. The public has used the owl's status under the ESA and the processes mandated under the National Environmental Policy Act (NEPA) (US Laws 1970) to move spotted owl management and management of public forests in the Pacific Northwest into the courts.

The purpose of this paper is to examine how current northern spotted owl management plans address the larger issue: conservation of old-growth forest ecosystems. In the process, it is necessary to outline some of the history of spotted owl management in the Pacific Northwest to understand how the laws, regulations and policy have driven management of the northern spotted owl and the old forest ecosystem upon which it depends.

Early Owl Investigations

In the late 1960s, little was known about the spotted owl. It was considered a rare or uncommon resident of the conifer forests of western Washington, western Oregon and northwestern California. In the summer of 1967, Eric Forsman, an undergraduate at Oregon State University, learned that by imitating the call of a spotted owl, the bird would predictably respond. Beginning that fall, Forsman and Richard Reynolds, a fellow undergraduate, began to search for spotted owls in Oregon. Their efforts revealed that the birds could regularly be located in old forests, including some sites where Marshall (1942) and Gabrielson and Jewett (1940) had found them many years earlier. Forsman and Reynolds brought their findings to the attention of Howard Wight, a professor at Oregon State University. In 1972, Forsman began a graduate program under the direction of Wight, also Leader of the Oregon Cooperative Wildlife Research Unit and a U.S. Fish and Wildlife Service (USFWS) employee.

Northern spotted owl *(Strix occidentalis caurina)*. Photo supplied by Oregon Cooperative Wildlife Research Unit.

Shortly after initiating field work, Forsman and Wight recognized the "handwriting on the wall": the northern spotted owl responded consistently from old forest stands, and these were the stands consistently slated for cutting. The habitat needs of the spotted owl were in direct conflict with the operative timber paradigm: cut the slow growing, but high volume and economically valuable, old-growth (200+ years) forest stands first and replace them with young, rapidly growing stands to be harvested on an economic rotation length of about 60–80 years. Wight brought the situation to the attention of the USFWS, USDA Forest Service, Bureau of Land Management (BLM) and the Oregon Department of Fish and Wildlife (then Oregon Game Commission).

Oregon Endangered Species Task Force

In 1973, USFWS revised the "Red Book" (US Dept. Interior 1973) which was a precursor to the official national list of endangered species; the spotted owl was included. Shortly after, John McKean, Director of the Oregon Game Commission, proposed that a professional interagency task force be formed to address endangered species management in Oregon. The objective was to prevent the necessity of listing any more species. The Oregon Endangered Species Task Force was formed in 1973 and, at the suggestion of Wight, agreed to address the needs of species associated with old-growth forests, with the spotted owl receiving first attention.

The Task Force recommended to state and federal agencies that 300 acres (121 ha) of old-growth habitat be retained around each spotted owl location as interim protection until statewide guidelines could be adopted. Note that the recommendation was to reserve a specific acreage on a site-by-site basis. While this was a logical approach given the information available at the time, it established a pattern of site-by-site reserves that was to be the operative paradigm for 15 years. The recommendation was rejected by both the Forest Service and BLM because they wanted a statewide population management goal established before proceeding further. At this time (1973) spotted owls had been located at about 100 sites in Oregon.

The Federal Endangered Species Act became law late in 1973 (US Laws 1973). The northern spotted owl was not included on the list of threatened or endangered species, thus the Act had no immediate impact on the management of the owl. The Act did, however, serve to establish a yardstick against which to measure species protection needs.

First Oregon Owl Plan

Regulations adopted pursuant to the National Forest Management Act of 1976 (US Laws 1976) directed the Forest Service to maintain well-distributed, viable populations of all native species on National Forests. Thus, not only was the Forest Service directed to keep from creating any new endangered species, it was directed to prevent amputating portions of a species' range. During 1976, the Oregon Endangered Species Task Force recommended a goal of maintaining "400 pairs of spotted owls on public lands in Oregon consistent with the specific habitat requirements of the species." The Task Force also indicated that it would "identify the number of spotted owl habitats and the distribution needed to maintain a viable population throughout their distribution in Oregon."

Early in 1977, both the Forest Service and BLM agreed to protect spotted owl habitat in accordance with interim Task Force recommendations. In late 1977, the Oregon Spotted Owl Management Plan was submitted to the various agency administrators for review and comment.

The plan called for habitat management areas that provided for clusters of 3 to 6 pairs, but permitted single pair management as well. A minimum of 1200 acres (485 ha) of contiguous habitat was to be provided per pair. Each pair was to have a core area of 300 acres (121 ha) of old-growth forest (or oldest available forest). At least 50% of the remaining 900 acres (364 ha) was to be in forest stands older than 30 years. Core areas for clustered pairs of owls were to be no more than 1 mile (1.6 km) apart, center to center. Management areas were to be a maximum of 8 to 12 miles (13 to 19 km) apart for multiple pair habitat areas, less for single pairs.

Management areas were allocated to agencies based on the area of land administered in western Oregon: Forest Service, 290 pairs; BLM, 90 pairs; State, private and National Park Service were expected to accommodate 20 pairs.

A major oversight was made in allocating pairs to BLM. Because of BLM's checkerboard ownership pattern of alternating square-mile blocks in western Oregon, BLM's lands were spread over twice as much area as a comparable acreage of Forest Service lands. The result was that managed owl sites on BLM lands were about twice as far from one another as on Forest Service lands. The plan also specified ranges for values for several criteria. It soon became apparent that only the minimum value in a range was operative when it came to land allocation for the conservation of the spotted owl. All the recommendations of this initial Oregon Spotted Owl Management Plan were devised without the benefit of radio-telemetry data from which to establish home range and habitat use.

Both the Forest Service and BLM agreed to implement the recommendations of the management plan via the agencies' ongoing land management planning processes. Final decisions as to the distribution, number and location of sites managed for owls were to be made with public involvement through NEPA mandated process. By 1981, National Forests in Washington were directed to provide protection to 112 pairs of owls.

Oregon Owl Plan Revised

In 1981, in response to new data derived from radio-telemetry studies by Forsman (1980, 1981) the 1977 Oregon Spotted Owl Management Plan was revised. The new recommendation was that 1000 acres (405 ha) of old-growth forest be maintained for each pair within a 1.5 mile (2.4 km) radius of the nest site. The 1000 acre figure represented the minimum acreage of old-growth forest found within the home ranges of 6 pairs of owls studied with radio-telemetry (Forsman and Meslow 1985); the mean acreage within the home ranges of those 6 pairs of owls was 2264 acres (916 ha), but the recommendation was for the minimum. The 1.5 mile radius represented the area within which most foraging by nesting pairs was accomplished.

These recommendations were forwarded to the Forest Service and BLM in Oregon. Region 6 of the Forest Service agreed to the new recommendations, but only to the extent that they would "maintain the option" to manage for 1000 acres if further research proved it necessary. BLM was not swayed by the new information and continued to protect habitat on only 300 acres (121 ha) for each managed pair.

In 1984, the Forest Service issued the final Regional Guide (USDA 1984) for the Pacific Northwest Region. The Regional Guide directed the National Forests to analyze the effect of protecting at least 375 pairs of northern spotted owls in Oregon and Washington. Shortly after, the Forest Service provided further direction for spacing requirements to maintain a well-distributed population; this increased to 551 the number of spotted owls proposed for management under Forest Service plans in Oregon and Washington.

The National Audubon Society formed a "blue-ribbon" advisory panel of scientists in 1985 to review the status of the spotted owl in Oregon, Washington and northern California. The panel recommended that a minimum of 1500 pairs of spotted owls be maintained in the 3 states, including the Sierra Nevadas of California, and that much larger acreage of habitat be protected for pairs of owls in the range of the northern subspecies (Dawson et al. 1986).

Fish and Wildlife Service Petitioned to List

In early 1987, USFWS received a petition to list the spotted owl as an endangered species under the ESA of 1973. A status review (USFWS 1987) was undertaken and in December 1987 the Service announced that listing was not warranted. The decision not to list was appealed to the Seattle Federal Court by conservation groups in 1988. The Court determined that the decision not to list was *not* biologically based, and ordered USFWS to readdress the listing decision.

In April 1988, the interstate and interagency successor to the Oregon Endangered Species Task Force proposed new management guidelines for the northern spotted owl. For the first time the guidelines addressed the entire range of the subspecies in Washington, Oregon and northern California.

The main features of the new recommendations were to provide significantly larger population centers, protect all remaining habitat in areas of special concern (such as the Oregon Coast Ranges), regenerate habitat in problem areas, maintain an interconnecting network of habitat areas of 1 to 3 pairs per township, retain an amount of habitat per pair that reflected the mean amount of old-growth forest within home ranges of radio-marked pairs, and provide for replacement habitat. Monitoring and interagency coordination were also addressed. These recommendations were not acted on by any of the agencies responsible for managing the owl or its habitat.

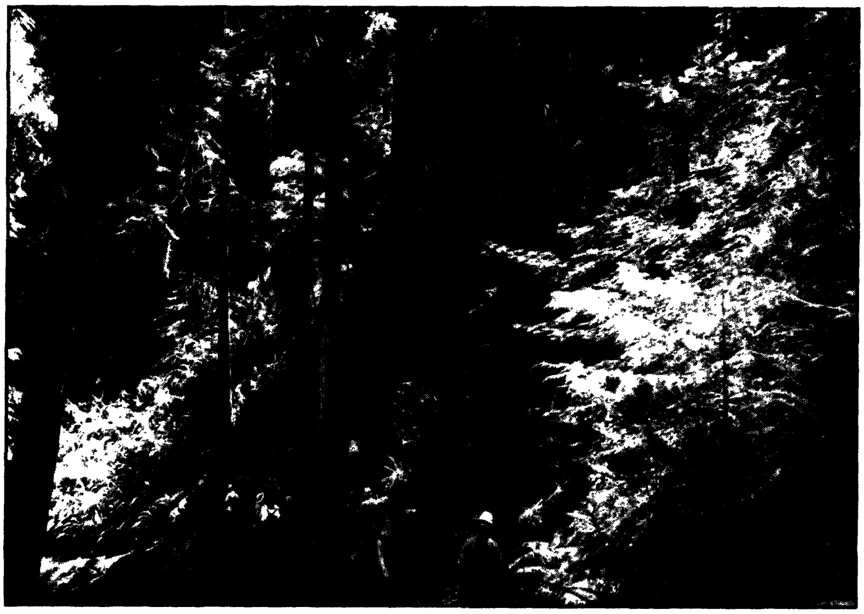
Forest Service Final SEIS

In late 1988, the Chief of the Forest Service issued a Record of Decision on the Supplemental Environmental Impact Statement (SEIS) for spotted owls for Oregon and Washington (USDA 1988). The selected alternative directed the 13 National Forests in Oregon and Washington with spotted owls to establish a spotted owl habitat network. Standards and guidelines varied by physiographic province.

Amounts of old forest habitat to be provided per pair in the network varied from 1000 acres (405 ha) in southern Oregon to 3000 acres (1214 ha) on the Olympic Peninsula of Washington. Habitat was to be identified within 1.5 miles (2.4 km) of the "core area" in Oregon and within 2.1 miles (3.4 km) in Washington. Habitat areas for 3 or more pairs were to be no more than 12 miles (19 km) apart; single pair areas were to be no more than 6 miles (10 km) apart. The Record of Decision was shortly appealed by the Washington Department of Wildlife and by both timber and environmental groups. The Assistant Secretary of Agriculture denied the appeals. (The Forest Service is part of the U. S. Department of Agriculture).

Interagency Spotted Owl Scientific Committee

As a result of the uncertainty surrounding the status of the northern spotted owl, the Forest Service recommended the formation of an interagency scientific committee to address the issue. The recommendation was agreed to by the heads of the BLM, Forest Service, National Park Service, and USFWS.



Pacific Northwest old-growth forest. Photo by E. Charles Meslow, Oregon Cooperative Wildlife Research Unit.

In October 1989 the Interagency Spotted Owl Scientific Committee (ISC) was established. The charge to the Committee was "to develop a scientifically credible conservation strategy for the northern spotted owl." The 17 member team drew representation from the four involved federal agencies, the three states, the timber industry, environmental organizations, and academia. The committee report, "A Conservation Strategy for the Northern Spotted Owl," (frequently referred to as the "Thomas Report" after the Committee chairman, Jack Ward Thomas), was completed and released in April 1990 (Thomas et al. 1990). The strategy is one directed specifically at the conservation of the northern spotted owl; it does not purport to address other species or the old forest ecosystem.

The ISC strategy calls for a system of Habitat Conservation Areas (on public forest land), each sufficient to accommodate 20 pairs of owls, distributed at 12 mile (19 km) spacing throughout the range of the northern spotted owl in the three states. No further timber harvest is to occur in the Habitat Conservation Areas and existing cutover areas are to be allowed to grow back.

The public forest area between the Habitat Conservation Areas (the "forest matrix") is to be managed to facilitate dispersal of owls between Areas. The 50-11-40 Rule establishes the appropriate forest condition: 50% of each quarter township (3 x 3 miles or 4.8 x 4.8 km), by public owner, is to be maintained in trees greater than 11 inches (28 cm) dbh (diameter at breast height) and greater than 40% canopy closure. The 50-11-40 conditions are routinely met under the usual economic forest rotations of 60 to 100 years in the Northwest. The report fine tunes this basic approach in problem areas. Importantly, the ISC Strategy called for a program of adaptive management, in the forest matrix, directed at developing silvicultural schemes which might allow persistence of the owl in a managed forest landscape. When such can be demonstrated, the Habitat Conservation Areas could be dissolved.

Table 1. A selection of 6 forest management options from the "Gang of Four" report (Johnson et al. 1991). "High Timber", from Forest Service and BLM planning documents, emphasizes timber production. "Latest Forest Plans" is the selected or most likely plans for National Forests and BLM Districts, as of October 1991. "Plans + Owls"is the Latest Forest Plans option and the ISC owl strategy, with application of the 50-11-40 rule. "Plans + Owls + Best Old Growth" includes the Plans + Owls option and the most ecologically significant old-growth and late-successional stands. "Add Fish Habitat" includes the previous option and management for sensitive fish species and stocks. "Add More Old Growth" includes the previous option and additional old-growth and late-successional stands. "Probability of sustaining" is graded as very low (VL), low (L), medium-low (ML), medium (M), medium-high (MH), high (H), or very high (VH).

			Probability of Sustaining				
Options	Allow Sale Billion (Bd. Ft.)	Job Loss (1,000's)	Functional Old Growth	Spotted Owls	Marbled Murrelets	Other Old Growth Species	Habitat for Fish
High Timber	4.5	2	VL	VL	VL	VL	VL
Latest Forest Plans	3.0	20-26	VL	L	L	VL	VL
Plans + Owls	1.7	35-40	ML	H	ML	ML	L
Plans + Owls + Best Old Growth	1.5	38-49	M	H	M	M	ML
add Fish Habitat	1.2	42-53	M	H	MH	MH	MH
add More Old Growth	0.7	48-60	VH	VH	H	VH	VH

The report of the ISC received wide distribution and scrutiny. The strategy calls for reservation of 5.8 million acres (2.3 million ha) of federal land previously not reserved from timber cutting. When taken in concert with the new set of Forest Plans, the resultant harvest of timber on federal lands in the range of the northern spotted owl would be about half the level of the 1980s.

The Owl is Listed

Following a third status review of the northern spotted owl (USFWS 1989), USFWS proposed listing the bird as threatened in April 1989. Following another review (Anderson et al. 1990), and addressing the extensive public comment received, USFWS listed the northern spotted owl as threatened throughout its range in June 1990.

The Endangered Species Act requires that a recovery plan be prepared for any listed species. The preparation of the recovery plan was directed by the office of Manuel Lujan Jr., Secretary of the Interior at that time.

The Recovery Team met regularly, beginning in early 1991, and delivered a draft plan to Secretary Lujan in mid-December 1991. Release of the draft plan was delayed until 14 May 1992. The Draft Recovery Plan (USDI 1992) closely resembles the ISC strategy. As one observer put it: "If you accept certain basic ecological principles, you find yourself on the yellow brick road, and you eventually end up in the emerald city."

The Recovery Plan does differ from the ISC strategy in several respects. The boundaries of habitat conservation areas were adjusted to better match existing habitat conditions; new habitat conservation areas were added along the Oregon Coast. An appendix evaluates the other old forest associated species and provides the biological background used to tailor the Draft Recovery Plan to accommodate "other species" while providing for the most economical recovery of the spotted owl. The Draft Recovery Plan thus provides the most current, in-depth appraisal of habitat requirements and risks faced by other old forest associated species. The Recovery Plan itself is not binding on any agency or entity; rather it sets the standard against which actions affecting recovery of the owl will be judged.

Coincident with the release of the Draft Recovery Plan, the Secretary of the Interior released an Administration sponsored "Owl Preservation Plan" drafted by Assistant and Deputy Assistant Secretaries of Agriculture and Interior. Their effort, dubbed by some the "Extinction Plan," mimics the Recovery Plan but amputates about 50% of the range of the owl. Scientists, assembled to evaluate the risk associated with this plan, indicated that there was a 50:50 chance of such management entraining a sequence of events that would lead to the extinction of the northern spotted owl.

Gang of Four Report

In 1991, several subcommittees of the U. S. House of Representatives requested four recognized forest experts with strong science credentials to provide an array of options (see Table 1) documenting the trade-offs between maintaining old forests, wildlife and fish and timber harvest. The experts, "The Scientific Panel on Late Successional Forest Ecosystems," were dubbed "the Gang of Four," and were soon joined by two fisheries/forest experts (Johnson et al. 1991).

The panel drew widely on existing agency, and other, expertise and data bases. The panel mapped habitat and devised reserves to accommodate non-timber resources and provided Congress with an array of options. The options ranged from high timber yield to high persistence probability for spotted owls, marbled murrelets (*Brachyramphus marmoratus*), and other old forest species; a functional late-successional forest network; and high quality fish habitat. Their report represents the first coordinated effort to present the trade-offs inherent in establishing an old forest ecosystem management plan.

The Gang of Four report indicated, importantly, that there was no "free lunch". Providing protection for both individual species and the old forest ecosystem comes at a cost, i.e., foregone timber harvest. For instance, accommodating spotted owls at the level recommended in the ISC strategy provided only a medium-low probability of sustaining marbled murrelets and habitat for sensitive fish stocks (Table 1). Increasing levels of protection for both the old forest ecosystem and sensitive fish and wildlife comes at considerable economic cost; but even the current set of National Forest Plans projects 1/3 lower timber cuts and 20–26 thousand fewer timber related jobs than during 1985-89.

The Gang of Four analysis offers an initial glimpse of what a Pacific Northwest ecosystem management plan might look like, and cost. The report is a broad brush approach which anticipated additional effort to tune the selected option to maximize local opportunities and minimize conflict areas. The Panel's report was also limited by the depth of information available for many old forest associated species and processes. It remains, however, a credible first approximation of the necessary lands and costs associated with maintaining a functional old forest ecosystem in the Pacific Northwest.

Evolution of Management Approach

Since the early 1970s, management for the northern spotted owl has served as a surrogate for old forest ecosystem management in the Pacific Northwest. The approach was largely unintentional; it was driven mostly by the Endangered Species Act; the National Forest Management Act and the NEPA process provided important support.


The marbled murrelet *(Brachyramphus marmoratus)*, a robin-sized seabird, is federally listed as threatened. Photo by Jeff Hughes, Arkansas Dept. of Fish and Game.

The history of spotted owl management in the Northwest can be viewed as evolution toward ecosystem management. Increasing the size of habitats deemed necessary to support single pairs of owls has in recent years been coupled with emphasis on reserves sufficient to accommodate many pairs of owls. The resultant large habitat blocks (conservation areas) are envisioned to maintain old forest conditions well-distributed on the landscape (albeit restricted to public lands). Maintaining the forest matrix between conservation areas in a forested condition that is hospitable, at least, to the needs of most forest wildlife offers broad connection between areas. The addition of fish habitat and riparian corridors, called for by the Gang of Four, considerably strengthens connectivity of the old forest system.

The considerable extent to which management for spotted owls seems to have succeeded in providing for the old forest ecosystem hinges on the remarkable habitat affinity of the owl for old forests throughout most of its range. Coupling the habitat affinity with the large area requirements that the animal demonstrates has driven the reservation of significant acreage of old forest within the range of the owl. The broad coincident distribution of spotted owls and old forests in the Northwest, and the large acreage and wide distribution of public forest lands, in concert, provide an opportunity for ecosystem scale management on public lands. The above scenario of the essentially fortuitous juxtaposition of law, biology and land ownership, has allowed the evolution of owl management to, or at least toward, ecosystem management.

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Putting the "E" Back in EPA

by

Jim Serfis

It is a commonly held notion that the mission of the U.S. Environmental Protection Agency (EPA), established in 1970, is to protect forests, lakes, estuaries, wetlands, and wildlife. To a great extent that perception is true. Mission statements and public pronouncements declare that EPA is dedicated to improving and preserving the quality of the environment. However, prior to 1988 the Agency mainly addressed ecological protection only as it was associated with the health of people.

Although EPA's first mission initially encompassed ecological concerns, the primary focus in the 1970s and 1980s was to protect human health from the adverse effects of pollution. A new emphasis for the 1990s is protecting aquatic and terrestrial ecological systems (EPA 1991). EPA has elevated the importance of taking a holistic approach to protecting ecological values. This approach includes activities as diverse as protecting specific ecosystems like the Great Lakes and the Gulf of Mexico, lessening impacts from urban and agricultural runoff, and preventing pollution (EPA 1992a). EPA's program offices and regions are contributing to this effort by including ecological considerations as they carry out regulations, research, education, and enforcement actions.

The reasons for this new emphasis may be obvious. Reducing risks to ecological quality offers the Agency one of its greatest opportunities to protect the environment. Arguably, each of EPA's primary statutory authorities directs the Agency, in differing language, to address the protection of the environment. While EPA does not have direct responsibility for management of physical habitat, it does have a range of authorities that can be used to greatly extend its effectiveness in protecting and restoring the quality of ecosystems. By focusing on whole ecosystems, environmental laws and programs can be put together in new ways that result in tangible benefits for the environment.

As the Agency rethinks its role in ecological issues, it has recognized its actions have major implications for endangered species. In addition to fulfilling consultation requirements, the Agency has begun to consider new ways to assist in recovery efforts and to further the conservation of endangered species. In a broader context, the Agency's ecological actions have a direct bearing on endangered species since these species benefit when ecological resources are better protected. Consequently, the Agency's new emphasis complements endangered species protection that focuses on multi-species management.

What Has Changed?

So if the name is the Environmental Protection Agency, why didn't attention to ecosystems remain a part of the Agency's actions since its inception in 1970? As a result of the wave of environmental laws passed around that time, EPA found itself in a reactive mode; the public would learn of an environmental problem, Congress would be persuaded to pass legislation, and EPA would then develop and implement regulations to resolve it (EPA 1990a). Consequently, EPA has focused mainly on managing the reduction of pollution as defined in the laws that it administers. The Agency's structure, not surprisingly, mimics the environmental legislation that it is required to implement, with program offices responsible for specific laws. In addition, the tools that it uses are narrowly crafted to reduce pollution using the emission controls called for in regulations (EPA 1990a).

While the environment benefits from EPA's success in improving the nation's air and water quality, the Agency's reactive mode precludes a thoughtful evaluation of what environmental problems are the most important, where they may occur, and how to reduce the likelihood of them occurring. To address these shortcomings, EPA began to change its planning and policies in the late 1980s.

The first concerted attempt to compare the relative risks of environmental problems and then consider which should receive attention was done by an interagency task force established in 1986. The task force's report, entitled *Unfinished Business,* concluded that the environmental problems judged to be the most serious for the country were not necessarily the same ones on which EPA was focusing its resources to solve (EPA 1987).

Although no major changes occurred immediately after the report was released, it did bring a modest shift in thinking within the Agency and more support for ongoing projects that had an ecological and natural resource component. These projects had started as an expansion of efforts by several program offices to protect values not directly related to human health. Examples include increased wetlands preservation, consideration of ecological effects when making clean-up schedules for Superfund sites, and consideration of endangered species and other wildlife when pesticide use was approved. These modest changes were the beginning of an increased attention to the ecological aspects of EPA's mission (EPA 1988).

Reducing Ecological Risk

If the *Unfinished Business* report was to bring a shift in the Agency's already changing agenda, then a follow up report was to serve as an even greater catalyst. *Reducing Risk: Setting Priorities and Strategies for Environmental*

Protection was completed by EPA's Science Advisory Board (SAB) in 1990. As an advisory group to EPA, the SAB recommended that EPA should attach as much importance to reducing ecological risk as it does to reducing human health risk. In ranking ecological risks according to their priority of importance, the SAB considered global climate change, habitat alteration, stratospheric ozone depletion, and biological depletion as the most serious risks to the natural environment (Harwell et al. 1992).

EPA's Administrator at the time, William Reilly, endorsed the findings of the SAB report, and the Agency has been taking a number of steps to comply with them. Just as importantly, the report has stimulated EPA decision-makers to reassess how regulations and actions can be used to protect ecological values.

Two important ongoing efforts initiated in response to the SAB report are the Framework for Ecological Risk Assessment and the Habitat Cluster. The Framework for Ecological Risk Assessment is a report describing a foundation for developing future risk assessment guidelines for ecological effects. While the framework and subsequent guidance are not regulatory requirements within EPA, it does offer a process for conducting and evaluating ecological risk assessment. These assessments are meant to evaluate the ecological effects caused by human activities.

The importance of making such assessments is that it assists in identifying environmental problems, establishing priorities, and providing a scientific basis for decisions (EPA 1992b). Ecological risk assessment, like human health risk assessment, is not an exact science and will take some time before it is used consistently by the Agency. In the short-term, however, it provides a way of thinking that will increase consideration of ecological issues in EPA's actions.

Habitat Conservation

The Habitat Cluster is an agency-wide task force formed specifically to respond to the SAB findings concerning habitat alteration. The Cluster's primary objective is to develop strategic options for the Agency to address habitat conservation in the context of EPA's legislated mission and programs. Another objective is to identify opportunities for cooperation with other federal agencies, states and private organizations.

While the cluster has already initiated some projects, its recommendations are currently being reviewed within EPA. The recommendations will provide program and regional offices with guidance on incorporating ecological values into their actions. The challenge for the Agency is to use its authorities and resources to continue the established human health programs while expanding more aggressively into ecosystem protection. While appearing to be contradictory, these two directions actually complement each other as the Agency meets its responsibilities.

EPA Authorities and Actions

To appreciate EPA's role in ecosystem protection it is helpful to understand applicable authorities and programs. EPA has a number of regulatory and non-regulatory authorities that provide the basis for greater involvement in ecosystem protection. Almost all EPA statutes contain broad enough authority to incorporate ecological considerations into EPA programs. While most of those authorities focus principally on chemical contaminants, they do include consideration of physical impacts. The following is a partial annotated list (Hirsch 1992) of examples of authorities and programs that illustrates the range of EPA's capabilities to protect ecosystems.

Regulating environmental pollutants. EPA has direct authority to regulate pollutants that could adversely impact ecosystems. Under the Clean Water Act, for example, EPA oversees establishment of and compliance with water quality standards, including standards designed to protect aquatic life. The Act contains other provisions that relate to aquatic life, including designation of Outstanding Natural Resource Waters of exceptional ecological significance, to which special protections apply. Under the Federal Insecticide, Fungicide, and Rodenticide Act, EPA regulates the use of pesticides. In registering pesticide use, EPA evaluates ecological as well as health effects. Pesticide use can be cancelled or restricted based on ecological and endangered species impacts.

Wetlands protection. EPA jointly administers Section 404 of the Clean Water Act with the Army Corps of Engineers. This is one of the Agency's most direct regulatory authorities for preventing physical alteration or loss of habitat.

Non-point source pollution. The Clean Water Act requires states to develop non-point source (NPS) management programs for EPA approval, although EPA does not have direct regulatory authority over NPS. Many Best Management Practices designed for NPS control also directly relate to habitat protection, such as establishment of riparian buffer strips.

Estuary management. Under the Clean Water Act, EPA coordinates development of comprehensive management plans to protect the water quality and ecological resources of significant estuaries. These programs involve coordinated efforts among federal, state, and local agencies and address physical habitat as well as contaminant concerns.

National Environmental Policy Act review. EPA has special authority under Section 309 of the Clean Air Act requiring it to review and comment on the National Environmental Policy Act (NEPA) documents and actions of all other federal agencies. EPA comments usually include ecosystem related concerns.

Environmental education and public information. Under the National Environmental Education Act of 1990 and other authorities, EPA has broad responsibilities to support programs of environmental education and training. Public information and outreach is a significant part of all EPA programs.

Environmental Monitoring and Assessment Program. The Environmental Monitoring and Assessment Program (EMAP) is designed to monitor indicators of the condition of the nation's ecological resources. Initiated in 1990, the program will measure trends in ecosystem condition and develop methods for anticipating emerging threats to those systems (EPA 1990b).

Geographic initiatives. The Agency targets particular geographic areas to focus its protection for an entire ecosystem. In the Chesapeake Bay, for instance, EPA has assisted in securing an agreement on a Bay-wide compliance monitoring and enforcement strategy and has provided financial and technical support for the clean up of one of the rivers that feeds into the Bay. In the Great Lakes, EPA has spent $6.6 billion dollars since 1972 to construct wastewater treatment facilities to clean the waters flowing into the Lakes. Similar work and the building of a coalition of public and private organizations has occurred in the Gulf of Mexico (EPA 1992a).

Endangered Species Protection

Integration of ecological protection into EPA's agenda also includes endangered species conservation. The Agency has begun to assess how more effective cooperation under the Endangered Species Act (ESA) can be accomplished. These efforts focus primarily on the consultation process and on recovery plans.

EPA can improve its role in species conservation by coordinating federal resources on recovery plans for specific species, consulting on possible effects, sharing toxicity information, and assisting in research. The Agency can do this on a species-by-species basis but will be more likely to have a greater impact if it takes a multi-species, or ecosystem approach.

The protection of ecological values and functions, especially in critical habitat, provides one of the best means of avoiding the loss of endangered species. To coordinate EPA's efforts, a committee was appointed by the Deputy Administrator to work in cooperation with appropriate program and regional offices to recommend how EPA could most effectively meet its obligations under the ESA.

New Opportunities and Teaching Old Dogs

EPA is in a unique position to leverage its resources to protect ecological functions and values. The Agency has at its disposal a committed workforce, scientific expertise, and broad mandates in its authorities and regulations. Despite having elevated consideration of ecological risk and expanded its ecosystem perspective, the Agency can do much more to integrate its programs to address environmental protection more comprehensively. Several suggestions are given to continue EPA's ecological efforts.

The Agency should establish its ecological niche. Although much progress has been made, the approach to date has lacked a strong, cohesive plan of action that targets ecosystems most at risk. By focusing on its particular expertise and resources, the Agency can contribute to ecological conservation efforts in ways not being done at present. The Agency can also be a role model for other federal agencies in efforts to protect endangered species.

Using EPA statutes to incorporate ecological concerns into EPA programs is where the "rubber meets the road". Because EPA's authorities are broad enough to incorporate ecological considerations into its programs, the Agency only needs to act "more creatively and assertively" in using them to protect ecosystems (Fischman 1992). With such diverse authorities, the Agency can have a tremendous influence on the protection of ecological systems. Using these authorities effectively will require the development of guidelines on how to determine ecological risk and measures to reduce this risk.

If EPA is to increase its effectiveness in protecting ecosystems, it will be critical to expand its coordination with other federal agencies. While the land management agencies may be the most obvious partners, working with other federal agencies may also have ecological benefits. Several examples of cooperative efforts include incorporation of federal agency ecosystem concerns in EPA geographic initiatives; cooperation in public education and outreach, research, monitoring, and training; and joint efforts to minimize habitat destruction resulting from federal activities.

One final suggestion concerns developing an ecological ethic in EPA. However surprising it may be, the Agency does not have many ecologists within its ranks and the majority of its workforce have a limited background in the natural sciences. To be successful, the Agency will need to encourage its personnel to think ecologically as they protect the environment. To do so means changing the way EPA does business. Taking an ecosystem approach is a more effective way to protect the environment and ultimately a more effective way to conserve endangered species.

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Application of Landscape-Level Conservation Biology Principles to the Lower Mississippi River Valley

by

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The premier challenge in conservation biology today is to implement theory in real world ecosystems. Partnerships and the development of shared visions are the minimal requirements for achievement.

Efforts are underway across the continent to achieve the level of cooperation needed to bring about lasting landscape-level accomplishments. The following is a discussion of one such effort, the Mississippi River Alluvial Plain Project. Although still in its infancy, it may provide an example of how such a process evolves.

Description of the System

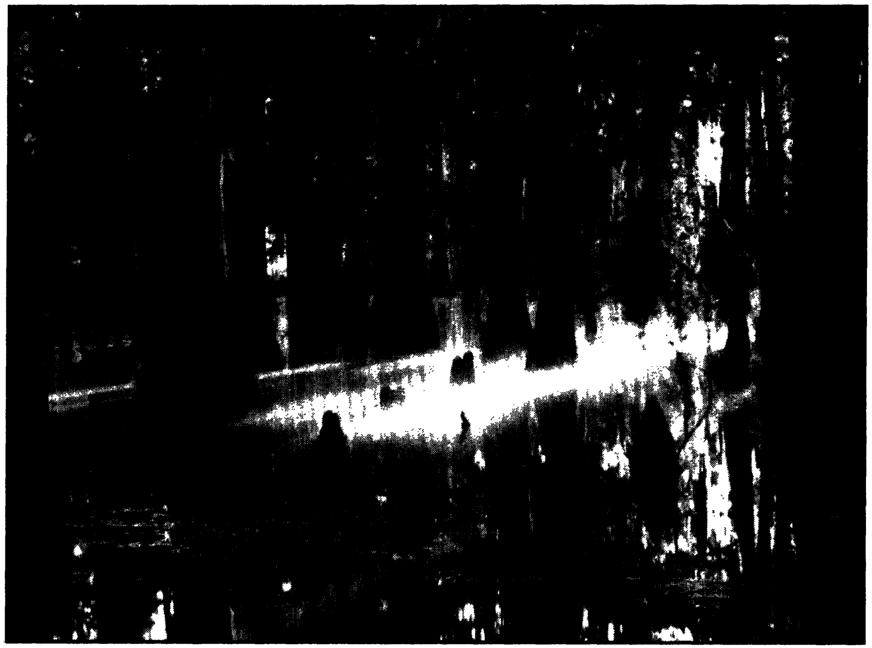
Bottomland hardwood forests (including bald cypress and tupelo swamp forests) are historically the dominant natural community on riverine floodplains of the southeastern United States. The greatest single expanse was in the 21 million acre floodplain of the lower Mississippi River Valley from southern Illinois to coastal marshes along the Gulf of Mexico. The biotic and physical features of this system are determined by hydrology and sedimentation (Bedinger 1981).

A key factor in the evolution of bottomland plants has been the ability to persist under anaerobic conditions when soil becomes saturated with water. As a result, the distribution of species within the community is dependent to a large extent upon the timing, frequency, and duration of flooding (Huffman and Forsythe 1981).

A complex series of levees, meander scrolls, sloughs, and oxbow lakes are characteristic of alluvial plains (Taylor et al. 1990). Bottomland forests typically flood as rising rivers back up into tributaries. As overbank flooding occurs and water spreads out and slows down, sediments and nutrients are deposited across the floodplain. The heaviest sediments drop out closest to the channel, resulting in natural levees that are higher and drier than land farther from the stream. Frequent meanders and changes in the main course of streams cause abandonment of these levees and flats and result in a complex topography of parallel ridges and swales across the floodplain.

There are other disturbances that influence plant distribution. As in other southern deciduous forest types, tree fall is common, perhaps exacerbated here by the plastic nature of the saturated soil. Winds aggravate this, and occasional tornadoes and other storm events can knock down the overstory on significantly sized areas. Prior to European settlement and increasingly so again now, beaver activity in bottomland hardwoods can cause frequent or even continuous flooding. And last, although not well-documented, bottomland forests may have been subject to infrequent fires.

Tanner (1986) reported on the tree species and size composition of a virgin bottomland hardwood stand in northeast Louisiana in which he studied ivory-billed woodpeckers in the late 1930s. He found that the hydric extremes (almost always flooded and almost never flooded) were very distinct, but that continuous change was evident in the distribution of species across intermediate zones. Most interestingly, he found a very large number of small, young trees, including those species that are intolerant of shade, throughout the system. Although old trees were numerous, accidental death and turnover were frequent but spatially variable, resulting in a highly uneven age distribution.



Autumn sunrise in cypress-tupelo habitat near the Mississippi River in Louisiana. Photo by Nancy Webb.

This contradicts notions of old growth bottomland hardwoods as static, unproductive communities consisting of a closed canopy of senescent trees. There is an emerging sense that old growth was a shifting mosaic of even-aged small patches of all ages, further complicated by minute differences in elevation and tolerances among a large number of woody plant species.

Historical Changes

The majority of wetland acreage in the continental United States at the time of European colonization was bottomland hardwood forest (Turner et al. 1981). Perhaps the earliest alteration in this system was caused by heavy trapping resulting in local extirpation of beaver from the seventeenth century onward. Other early changes in flooding regimes occurred as streams were cleared of snags and obstructions to improve navigation. Levees were built to control flooding; by 1828 levees along the Mississippi in south Louisiana were essentially continuous (McPhee 1989).

Reduced flooding made agricultural endeavors more feasible, so more land was cleared, drained and farmed. Federal government programs encouraged this conversion (Turner et al. 1981). Timber in the last extensive virgin stands was harvested in the 1940s. High soybean prices drove more clearing, often producing marginal agricultural land, in the 1960s and 1970s. Changes in economic conditions and government programs have greatly reduced the rate of clearing and conversion since about 1980. Most recently there have been some small-scale efforts at reforestation.

The loss of bottomland hardwoods is perhaps five times higher than for any other major hardwood forest type in the United States (Abernethy and Turner 1987). Estimating the current area of remaining forest is difficult; the best available figure for the Mississippi River Valley is 4.9 million acres (Creasman et al. 1992).

Sheer acreage is not the only measure of loss. Because of changes in flooding and disturbance and various histories of management, tree species composition and age distribution as well as the condition of cavity trees, etc., are probably very different from pre-settlement conditions. Perhaps more critically, much of what is left consists of fragments embedded in a sea of agriculture. Loss of habitat in general, as well perhaps as changes in the character of that forested habitat that remained, brought about the extirpation of the ivory-billed woodpecker, Bachman's warbler, red wolf, and Florida panther.

Although a gross reduction in populations resulting from habitat changes probably occurred, there is question as to whether populations are continuing to decline in the fragmented and altered habitat that remains. In an analysis of Breeding Bird Survey data for the 25-year period from 1966 to 1990, Wiedenfeld et al. (unpubl. ms.) found that the Mississippi Alluvial Plain was one of five physiographic areas in the continent in which populations of more than 2/3 of the species studied declined. Declining species include interior forest birds such as the prothonotary warbler, and also second growth or edge species such as the orchard oriole and yellow-breasted chat. Because much of this occurred during a period when the availability of forested habitat remained fairly stable, it is possible that some other factors were at the root of these declines. A simple explanation based upon deterioration of winter grounds is unlikely in that the declining species use different habitats in different regions. These declines illustrate the need to consider detailed land management issues as well as the dramatic impacts of large-scale land clearing.

Biological Goals

The biological goals for the Mississippi River Alluvial Plain are:

(1) Protect and restore sufficient acreage to sustain the full range of biological diversity in each of the basins of the Mississippi River Alluvial Plain.

(2) Restore natural hydrology to significant segments of the region and improve it elsewhere sufficiently to ensure most wetland values; improve water quality throughout to meet all pertinent standards; protect viable populations of all indigenous aquatic organisms.

(3) Provide sufficient breeding and migratory habitat to support stable or increasing populations of all species of forested wetland birds.

(4) Support viable and sustainable populations of black bear in all basins within their historical range; support at least one population each of panther and red wolf.

If the institutional framework is sufficient, if information management and research provide answers to ever-changing needs, if partnerships are nurtured and are fruitful, if the conundrum of compatible use is solved, and if identified conservation goals are achieved, then the ultimate vision for the Mississippi River Alluvial Plain, these biological goals, should occur on their own. Failure at this level would reflect poor planning and implementation at lower levels.

Solutions and Strategies

Correction of these ecological problems needs to be undertaken from a landscape perspective, with implementation occurring largely at local levels. Among the first requirements is a definition of goals and a desired future condition.

Successful accomplishment of five groups of goals–institutional, information, partnership, compatible human use, and conservation–should bring about the desired future conditions, which, in turn, are the biological goals of this program (See Box). These various levels can be undertaken simultaneously with the understanding that accomplishments at any given level hinge on progress at lower levels.

Institutional Goals

The most basic component of any conservation initiative is the institutional support behind it. The most important part of this support is people with resources dedicated to the project. These people obviously need time, office space, equipment, funding, etc. This dry topic must always be considered when setting other, higher level, objectives. The best of plans are of little value unless there is an institutional structure and commitment sufficient to implement them.

The Nature Conservancy has a field office in each of the seven states of the Alluvial Plain. Headquartered in Louisiana (and working in all the states of the Valley) are a Project Director, a fully-equipped GIS Coordinator, a Black Bear Coordinator, and two half-time interns devoted exclusively to this project as well as other staff providing them with support, supervision, and assistance.

Informational Goals

Efforts to restore or manage a naturally functioning alluvial forest system are doomed to at least partial failure if the nature of that system is poorly understood. Because of the dramatic changes in the landscape and research concentration on anthropocentric values rather than natural functions, it is difficult to precisely describe a desired future condition for any particular place in the Valley. First steps toward correcting this situation include a review and compilation of scattered literature and data, and a description of those remnant forests that may serve as models. This proposed survey and characterization of forested wetlands of the Lower Mississippi River Valley will identify information gaps that can direct research as well as guide conservation efforts.

One powerful informational tool currently under development is a Geographic Information System (GIS) for the entire Valley. This system will initially include a spatial inventory of land use (including remaining forested patches), roads, streams, political and watershed boundaries, public lands, and general soils. In addition to compiling current information for planning purposes, the GIS will be used to build an institutional tracking system. This will provide for a continuous updating of information about activities that cause ecological change as well as a historical record to provide continuity of conservation planning.

Partnership Goals

No project of this magnitude will enjoy significant success without the cooperative efforts of a broad spectrum of partners. Achievement of goals will involve, for example, changes in land use, water management, and land ownership. Many federal and state regulatory and management agencies have mandates in these areas. The suggested changes will take place on private or public lands currently managed by thousands of individuals or entities with widely varying land use objectives. Dozens of private organizations have advocacy interests in the region. Many of these diverse agencies, individuals, corporations, and organizations have shared or overlapping goals. The challenge is to create a communication network in which shared goals can be built into common visions for the region and then implemented locally using the skills and resources of the partners.

As in most of the eastern United States, the vast majority of land in the Delta is in private hands. There are two ways to induce a private landowner to modify land use practices. The first is through regulatory restrictions. This is occurring, but is generally unpopular among those directly affected. The second is through incentives or opportunities that encourage the landowner to recognize and undertake a positive alteration of practices. A major challenge of this landscape protection effort will be to develop opportunities for environmental improvements that are in the best interest of, not only the ecosystem and society, but also of the private landowner.

One of the most promising of the developing partnerships is the Black Bear Conservation Committee (see *Endangered Species UPDATE* Vol. 10 No. 2). Timber companies, conservation organizations, and government agencies have worked closely together to nurture a program of education, law enforcement, research, land acquisition, and management recommendations and changes designed to restore populations of the Louisiana black bear.

Another partnership with a bright future, Partners in Flight (PIF), has the goal of reversing population declines of Neotropical migratory birds. In the Mississippi Valley, these birds, just as black bears, need more forested habitat managed at least partially for natural values. Because of pronounced declines in many species there, the Southeastern management group of PIF has designated the Mississippi Alluvial Plain as an extremely high priority area. An early benefit of this partnership is a coordinated program of research designed to learn the effects of fragmentation and varying management strategies on the reproductive success of these birds throughout the Valley. Cooperators include biologists from several universities, federal agencies, and conservation organizations. Meanwhile, the Arkansas and Tennessee state wildlife agencies are taking a lead in redirecting resources to non-game issues, specifically Neotropical migratory birds. On the federal side, a new National Wildlife Refuge in Louisiana (Bayou Cocodrie) will be the first dedicated specifically to providing habitat for forest-dwelling Neotropical migratory birds. A workshop targeted at federal land managers is scheduled for August 1993.

While the scope of these two examples is topical, other issues are better addressed on local geographic scales, specifically the sub-watersheds that make up the Alluvial Plain. Progress in forming working groups varies among basins with the greatest success thus far in the Cache of southern Illinois, the White/Lower Arkansas of Arkansas, and the Tensas of Louisiana (described later in this article).

Compatible Human Use Goals

Resource use patterns, alleviation of socioeconomic woes, and ecosystem conservation are inextricably linked. Opportunities need to be developed to improve the quality of life, to assure sustainability of the resource base, and to protect biological diversity.

Much of the economy of the Mississippi River Alluvial Plain is dependent on the region's natural resources. Although the agricultural, timber, and other products from the region have helped enrich the nation, poverty rates in the Valley are among the highest in the United States. Unemployment in West Carroll Parish, Louisiana, has approached 25%; per capita income in the Delta of Mississippi has averaged a third less than national averages; the poverty rate in Tunica County, Mississippi has been as high as 52.9% (Lower Mississippi Delta Development Commission 1989).

Agriculture is and will remain a mainstay of life, but the agricultural economy and the impacts of agriculture on the land both need to be improved. Incentives for farmers to reforest marginally productive lands help the landowner as well as ensure viable ecological communities. Sustainable agriculture practices can protect soil, reduce harmful runoff, and save the farmer money.

The Mississippi River Alluvial Plain's timber constitutes one of the area's greatest natural (or ecological) resources, and consequently one of its great economic assets. Timber management also is one of the Delta's most ecologically compatible and sustainable economic activities, and one which is consonant with the culture of the region. Additionally, in cleared areas where agriculture has proved uneconomic, reforestation is a key to returning lands to economic productivity, while improving ecological functions such as migratory bird habitat and water quality. Production of wood products using wise silvicultural and ecological methods can generate income while providing quality wildlife habitat. For example, long rotation and selective cut management can simulate natural disturbance regimes and essentially accommodate the entire spectrum of native biological diversity. This practice is being implemented with economic success on the extensive holdings owned and managed by the Anderson-Tully Company.

Tourism may be the leading industry in the world by the year 2000, and nature-based tourism is already the biggest part of that industry (National Park Service 1991). Already expenditures related to sport hunting and fishing provide a large amount of economic activity in the Mississippi River Alluvial Plain. In Louisiana, citizens annually spend 112 million active days fishing, hunting, boating, etc. - an average of 25 days per person in the state. In 1985, Arkansas residents spent an estimated $30 million for expenditures related to migratory bird hunting. In Mississippi, 1.5 million citizens, 63% of the state's population, participated in non-consumptive wildlife resource activities during 1985-86. Outdoor recreation is now a prime activity of residents of the Valley, and protection and increasing awareness of the system's natural values can attract more visitation, thereby improving both local quality of life and economic activity.

The linkage between ecology and economy must be fostered and the two need to be viewed as compatible rather than competing objectives. This is a big challenge in any landscape conservation initiative.

Conservation Goals

Achievement of conservation goals results in actual changes in the management of lands and waters that bring about desired responses in populations of organisms and functions of systems. All of the prior goals lay the groundwork for conservation goals, and achievement of conservation goals in turn should lead directly to the ultimate biological goals. All conservation goals should be considered from a landscape perspective; at the same time, most conservation goals are implemented at a very local level.

Land acquisition by public agencies has been an important component of system protection. Additional purchase of key tracts, particularly those that would reduce fragmentation and increase connectivity, should continue as budgets allow. The Nature Conservancy has assisted the U.S. Fish and Wildlife Service in establishment or significant expansion of nine National Wildlife Refuges in the Mississippi Valley over the past five years. Carefully targeted acquisition followed by appropriate management will continue to be a priority.

The optimal condition of any particular piece of land in the Valley is to be part of a large forested tract on which a natural disturbance regime maintains a shifting mosaic of relatively even-aged patches of the size of treefall gaps and of a great variety of ages. A hands-off, passive management strategy should be adopted where possible, such as on public lands, or on private, non-industrial forest sites on which the owner chooses to manage for biological diversity. Naturally occurring disturbances will inevitably create habitat for early successional species.

Landscape planning must reflect the fact that the vast majority of land will remain non-public. A wide range of conservation tools is available for application to these private lands. Easements and management agreements can assist and commit landowners to appropriate courses of action. Incentive programs such as the Wetlands Reserve Program and Conservation Reserve Program can provide landowners with financial assistance to convert marginal, wet agricultural land back into forest. Other "green subsidies" for the private landowner should be explored. The prime objective for a landowner is clearly not always going to be protection of natural features. Within any set of objectives, however, there are potential improvements to land management and its impact on ecosystems.

Highest priority use for much private forested land in the Valley is production of timber. The three broad categories of silvicultural practices that managers of these lands can choose among are large clearcuts (or other practices such as shelterwood or seedtree cuts in which large areas are essentially cleared), group selection or small clearcuts, and individual selection of trees. Because of species-specific habitat preferences, no single choice will have a similar effect on all native flora and fauna, and each practice will provide benefits for at least some species.

Although clearcuts will provide habitat for some edge-dwelling species, they will not provide suitable habitat for many forest-dwelling species. However, if it is necessary to extract a given volume of timber from a stand, it is quite possible that a single clearcut is preferable to multiple small clearings, in that the single cut will create a much shorter linear distance of edge. Negative effects of clearcuts can be mitigated to some extent by a lengthening of the rotation period.

Group selections, in which areas from about 1/4 acre to one acre are cleared, mimic in some ways a natural disturbance regime. Preliminary studies have shown good densities of the full range of forest migratory birds on at least some of these lands that are managed in an economically viable manner. Larger group selection cuts may have all the negative features of clearcuts with the added impacts of greater edge and more roads.

Individual tree selection more closely mimics treefall disturbances. This method may cause very little damage to a system if trees are harvested in the same size and species ratios as those existing in a natural forest. Diameter cuts in which all individuals above a certain size are harvested, however, will ultimately change a forest's species composition usually in a silviculturally and ecologically negative manner.

Gap in a virgin bottomland hardwood forest in the mid-1930s in the Tensas basin. Photo by James Tanner.

Regardless of the harvest practice chosen, caution should be exerted to ensure the health of what remains. Most states have Best Management Practices (BMPs) that were developed primarily to prevent non-point source water pollution from silvicultural activities. The BMP concept can be expanded to incorporate many other kinds of natural resource objectives, including biological diversity. Whereas sensitive practices can leave a relatively intact ground cover from which prompt regeneration can be expected, heavy disturbance of soils will stimulate the establishment of weedy species, slow regeneration, and create unfavorable conditions for most native species.

Lands that are in active agricultural production can be managed to reduce negative impacts through, for example, buffer strips or restraint in chemical application to maintain water quality, retention of riparian and other appropriate areas as woodland for some wildlife habitat, or leaving water on the ground in the non-growing season to provide migratory water bird habitat.

Managers of land that has been in agricultural production should consider the benefits of reforestation. Many reforestation issues revolve around soils and hydrology and the nature of the plant community appropriate for a site. Choosing the proper species for regeneration is critical to success. Reforestation is one of many local activities important in management decisions at watershed, regional, ecosystem, or landscape scales. In general, reforestation will do the most good adjacent to existing forested tracts by increasing patch size and reducing fragmentation. Reforestation along streams will increase connectivity, improve water quality, and provide movement corridors for some wildlife and plant propagules.

Hydrological restoration can be as important as reforestation for the overall health of the system. This is a critical issue for which we have not developed sufficient understanding. Any successes that will ultimately be achieved will result in large part due to cooperation with the U.S. Army Corps of Engineers.

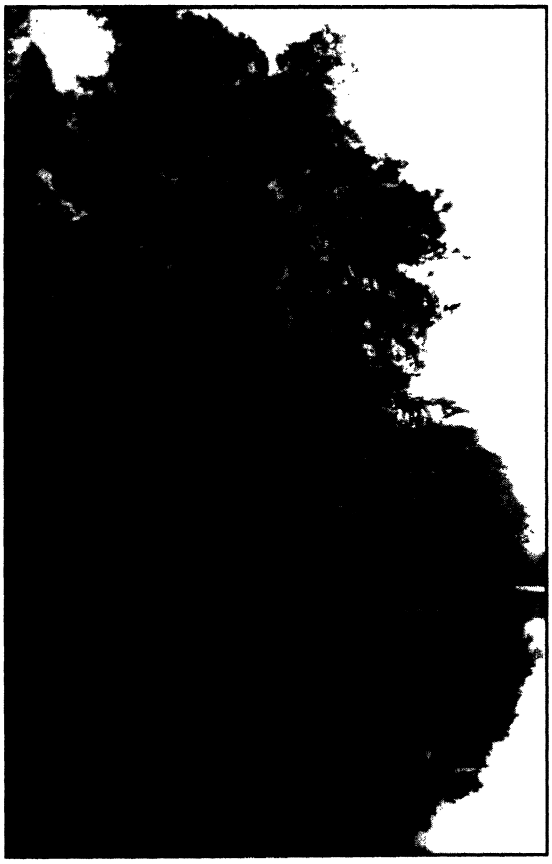
All management decisions of consequence should be made at large scales, with perhaps the physiographic area considered a management unit (Sharitz et al. 1992). Decisions made at an individual refuge or other small component of an ecosystem may or may not be wise from the perspective of a larger, more relevant geographic scale. Maximizing species diversity of a refuge, for example, often has the unintended effect of reducing regional species diversity by encouraging widespread habitat generalists at the expense of narrowly distributed specialized species.

Tensas Basin Cooperative Effort–A Case Study

The Tensas Basin, located in northeast Louisiana and southeast Arkansas, exemplifies the predominant landscape found today in the lower Mississippi Valley. According to 1987 land use statistics, bottomland hardwood forest in the Louisiana portion of the Tensas basin has decreased 85% since presettlement conditions from approximately 2.5 million acres to less than 400,000 acres. The conversion of land use, primarily to agriculture, has resulted in forest fragmentation, poor water quality, bottomland hardwood forests that are flooded less frequently and for shorter periods, and the decline or extirpation of certain species.

In response to the scope and scale of environmental problems in the region, a comprehensive, cooperative effort is being initiated to develop a watershed protection plan for the Tensas basin. The rationale for development of a landscape level plan here is based upon a number of factors. The basin contains the largest publicly protected forested wetland expanse in the Mississippi River Alluvial Plain, the Tensas River National Wildlife Refuge, a 59,000 acre area that provides habitat to the endangered Louisiana black bear and other declining faunal elements. Numerous studies have been conducted in the basin and a limited GIS database compiled, providing baseline information for a landscape level study. And perhaps most importantly, a shared vision and willingness to cooperate exists among the stakeholders.

The multi-agency, multi-landowner, multi-organization initiative designated the "Tensas Cooperative Effort" evolved out of originally independent projects. For example, The Nature Conservancy (TNC) started the "Mississippi River Alluvial Plain" project in 1989. Since then, TNC, the Environmental Protection Agency, and the Louisiana Department of Environmental Quality have joined together to develop a watershed protection plan for the Tensas Basin.



Edge of an oxbow lake in alluvial forest habitat in the Tensas basin of northeast Louisiana. Photo by The Nature Conservancy of Louisiana.

An integral component of the TNC/LDEQ/EPA project is coordination with other agencies, organizations, and most importantly the landowners. As a result, additional projects have been instigated in the Tensas Basin. The Soil Conservation Service targeted the area for a "River Basin Study" that involves detailed inventory, public outreach, and recommendations for future work. The Louisiana Soil and Water Conservation Committee is also focusing attention on the region by hosting educational "field days" that bring farmers together at model farm sites. The Louisiana Agricultural Stabilization and Conservation Service has received funding to initiate a water quality incentive program that will provide cost-shares to landowners who implement water quality improvement practices on their farms. The success of each of these projects depends on continuous coordination and communication among all of the participating parties and with the public.

Perhaps the most exciting and unique outcome of the groundswell of participation and interest in watershed planning for the Tensas region is the decision by the Tensas Cooperative Effort participants to establish a "basin coordinator" position.

Participants are developing a job description and contributing funds toward hiring a coordinator who will work to reduce duplication of effort among the many ongoing initiatives in the basin, but most importantly will act as a liaison between the project participants and the private sector. Landowner and/or community input, involvement, and support is critical to the success of this project.

An effective, supported watershed plan will take years to produce. The planning process will be ongoing, iterative, and involve constant review. However, due to the level of participation and cooperation in the Tensas Basin, great inroads are being made towards applying landscape ecology principles to real world situations and opportunities for restoration and protection.

Conclusions

Ecosystem conservation, or the various synonyms used for it here and elsewhere, is a noble goal. Progress is impeded by profound ignorance as to how ecosystems work and how human populations and those workings can be positively integrated. Conservation biology will be a worthwhile and robust endeavor if it can bring scientists, conservationists, resource managers, policy makers, and ordinary citizens together to address these problems.

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Great Lakes Intergovernmental Cooperation: A Framework for Endangered Species Conservation

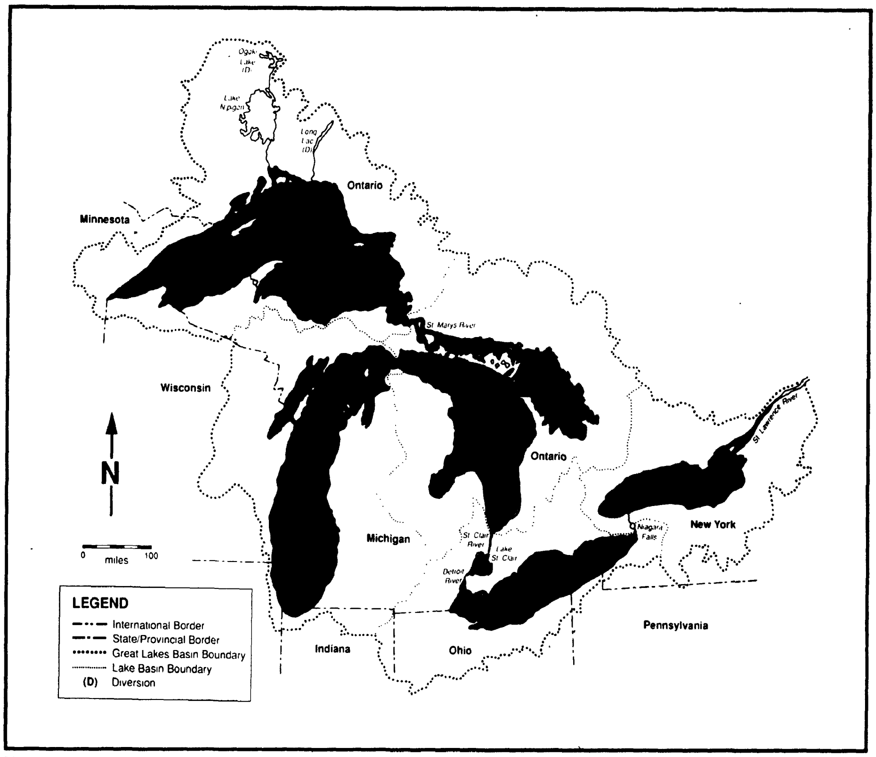
by

Susan MacKenzie

The Great Lakes have been identified as an extraordinary natural resource with unique value since the earliest North American explorations. With a total surface area of more than 246,000 square km (95,000 square miles) the five Great Lakes contain approximately 20 percent of the world's surface fresh water supply, and 95 percent of the surface fresh water in the United States. From its western to eastern borders, the Great Lakes span 3,862 km (2,400 miles) with over 16,090 km (10,000 miles) of coastline, leading to its designation as the fourth coast of the United States. It is home to a wide variety of terrestrial and aquatic plant and animal species. Clearly its magnitude distinguishes the Great Lakes region as an exceptional challenge for natural resource managers.

Additional characteristics of the Great Lakes make this challenge more complex. Although the Great Lakes system is huge, its drainage area is relatively small. Despite its low land to water ratio, four of the twelve largest cities in the United States are located on the shorelines of the Great Lakes. Needless to say, the growth of these population centers and pressures on the shoreline development have stressed the Lakes and their resident species.

Furthermore, the Great Lakes have a relatively long water renewal period. Water renewal is one measure of the amount of time it takes a lake to flush its entire system. It has been calculated to take over three hundred years for water entering Lake Superior to flush through the system and out the St. Lawrence Seaway. This heightens the Great Lakes' sensitivity to pollutants, and has great implications for the discharge of persistent contaminants into the system.



The Great Lakes and bordering states and provinces. Map provided courtesy of the National Fisheries Research Center–Great Lakes.

Beyond the complexities of the physical system, the institutional framework for managing the Great Lakes ecosystem is a maze of agencies and programs governed by two national governments, eight states, two provinces, and a myriad of local jurisdictions.

Like many major water systems in North America, the Great Lakes have not been immune to resource management problems. Deterioration of the natural resources of the Great Lakes has occurred since frontier development. During the 1800s, for example, the direct discharge of domestic sewage, vessel waste, and industrial by-products into the Great Lakes was an accepted practice. Since the turn of the century, by-products of industrial development, including oils, phenols, and cyanides, and nonpoint pollution have altered Great Lakes water quality significantly.

Beeton (1965) and Sonzogni et al. (1983) have documented widespread changes in the fish population of the Great Lakes since the mid-nineteenth century. These changes include the loss of Atlantic salmon due to diminished reproductive habitat; introduction of the sea lamprey which preys on game species such as lake trout and whitefish; and health advisories on the consumption of Great Lakes fish as a consequence of the bio-accumulation of chemicals in their adipose flesh.

In response to these water resource problems, the governments of Canada and the United States sponsored numerous scientific studies and implemented various remedial measures. Yet despite an ambitious research agenda and international pollution abatement initiatives, degradation of the Great Lakes continued (Francis and Regier 1979). It became clear that contemporary approaches were insufficient to redress the pollution problems in the Great Lakes. Instead, a more "holistic" water resource management policy was needed to replace the "reductionist" approach (Regier

1979).

Accordingly, when the Water Quality Agreement between the United States and Canada was reviewed and expanded in 1978, it was also recast to emphasize an ecosystem approach to Great Lakes management. Specifically, its statement of purpose was "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem. In order to achieve this purpose, the parties agree to make a maximum effort to develop programs, practices, and technology necessary for a better understanding of the Great Lakes Basin Ecosystem and to eliminate or reduce to the maximum extent practicable the discharge of pollutants to the Great Lakes System" (International Joint Commission 1988).

Principles of Ecosystem Management

The ecosystem approach is distinguished from previous resource management efforts in a number of ways:

1. **A primary focus on ecological integrity.** The objective of the ecosystem approach is to protect the integrity of the natural system. As such, the alleviation of stresses on a natural system is a prime goal. This may be accomplished through a combination of behavioral changes and technical solutions.

2. **A perception of the ecosystem as somewhat self-sustaining.** The ecosystem approach embraces the notion that humans and nature are part of the same interactive system, that the environment has threshold limits to stress tolerance, and responds synergistically to external influences.

3. **A natural ecological boundary.** The ecosystem boundary is determined by the nature of the resource to be managed rather than the arbitrary jurisdiction of a political unit. Within the defined ecosystem, all biological, physical, and chemical matter exist in a complex relationship of interdependence.

4. **A holistic orientation toward resource management.** Ecosystem planning and management recognizes that all elements of the system should be planned for in unison. Water, forestry, air, and wildlife concerns should be balanced with issues such as land use and industrial development in order to develop an ecologically sound and sustainable socio-physical system. Thus the ecosystem approach moves from a reductionist single-purpose orientation to a more holistic and inductive form of resource management.

Implementing Ecosystem Management Policies

There is much uncertainty associated with ecosystem management. Clearly, the implementation of a policy promoting ecosystem management has many implications for Great Lakes governance. For example, instead of the conventional single problem approach to pollution control, wildlife management, species conservation, and land use regulation, the ecosystem approach calls for the interaction of a wide array of programs across jurisdictions and from all levels of government, along with substantive participation by the public and industry.

The magnitude of the ecosystem challenge is reflected in the wisdom of the Great Lakes Research Advisory Board (1978, p.6) which noted that, "in terms of management practices, [ecosystem planning and management] demands a conceptual transformation from one mindset to another, something not easily achieved without an attendant educational process. This evolution is long overdue....Past experience suggests that it cannot come about in a piecemeal fashion. It must be grasped as a whole."

In fact, in accordance with the principles of ecosystem management, Remedial Action Plans (RAPs) are presently being devised for forty-three Areas of Concern (AOC) across the Great Lakes. The goal of the innovative Remedial Action Plan initiative is to restore beneficial uses to extraordinarily degraded areas using the ecosystem approach. Hartig and Vallentyne (1989, p.425) note that the Remedial Action Plan, "offers a unique opportunity to break down institutional barriers at a practical level. All affected organizations, agencies, and communities must work together on common goals and objectives, explicitly accounting for interrelationships between ecosystem compartments."

Specifically, each RAP must undertake the following list of activities: define the environmental problem and geographic extent of the area affected; identify beneficial use impairments; describe causes and sources of problems and pollutants; identify proposed remedial actions; define a schedule for implementing the remedial actions; identify jurisdictions and agencies responsible for implementation; describe the process for evaluating the remedial program implementation; describe surveillance and monitoring activities to track program effectiveness.

Several Remedial Action Plans are sufficiently advanced to answer some questions about applied ecosystem management, especially with regard to the issue of intergovernmental cooperation. The Remedial Action Plans in Hamilton Harbour, Ontario; Saginaw Bay, Michigan; and Lower Green Bay, Wisconsin were the subject of intensive on-site analysis in 1990 (MacKenzie 1991), when a total of thirty RAP participants in the three Areas of Concern were interviewed.

Intergovernmental Cooperation

If an "ecosystem approach" to endangered species conservation is used in the Great Lakes, various agencies and organizations from different governments will need to come together and form plans. The RAP process is an example of such groups coming together to use an ecosystem approach to improve degraded water resources. By examining the process and its results, we can gain important insights into the nature of intergovernmental cooperation for large scale ecosystem-level management. This may be the best example of how cooperative efforts could work for an ecosystem approach to endangered species conservation in the Great Lakes.

Among all RAP participants, intergovernmental cooperation was unanimously acknowledged as an important element of the RAP process. In each Area of Concern, a unique institutional framework was established to facilitate government participation. For example, Lower Green Bay created an implementation committee and four technical advisory committees, with membership from federal, state, and local (county and city) levels of government. Hamilton Harbour established a writing team of representatives from provincial and federal government agencies who, along with a stakeholder group of federal, provincial, regional, and public-private representatives, shaped the RAP plan for that Area of Concern. Under the direction of the Michigan Department of Natural Resources, the Saginaw Bay RAP created a steering committee of representatives from the counties and public in the drainage basin, and assigned the regional planning agency in the Area of Concern to serve as coordinator.

As conceptualized in the Remedial Action Plan initiative, ecosystem management clearly holds the potential for increasing intergovernmental cooperation. Indeed, among most agencies which have participated in the effort, the level of intergovernmental cooperation has reportedly increased. In particular, the comments regarding intergovernmental coordination were generally positive among the Lower Green Bay and Hamilton Harbour RAP participants. For example, one person noted that the RAP experience has broadened the number of people in different agencies with whom he interacts.

Of the three RAPs, the Lower Green Bay effort was most effective in providing a mechanism for intergovernmental participation. Their framework of implementation and technical advisory committees enabled individuals from federal, state, and local government to influence both the process and content of the RAP throughout all stages of development. By contrast, the Saginaw Bay effort had the weakest intergovernmental strategy. Instead of bringing individuals from all levels of government together to discuss the RAP in a group setting, the Saginaw Bay process distributed progress reports to regional experts who reviewed and commented on the documents as needed. Thus, with the exception of the county representatives to the steering committee, participation was limited, and the enhancement of intergovernmental relationships was forfeited.

On the question of intergovernmental participation, the Hamilton Harbour experience fell somewhere between the experiences of the Lower Green Bay and Saginaw Bay RAPs. The stakeholder forum provided a useful place for individuals from different levels of government to interact. Thus, the Hamilton Harbour RAP was strong relative to Saginaw Bay. However, the writing team, by virtue of their task, had an enormous amount of influence on the RAP document. Local government agencies were not included on the writing team. Thus, by comparison with Green Bay, the Hamilton Harbour RAP was somewhat deficient.

Nevertheless, RAP participants in Hamilton Harbour described significant advances in federal-provincial intergovernmental relations. As a result of the RAP effort, the federal Environment Canada and provincial Ontario Ministry of Environment reportedly developed a noticeably stronger working relationship at both the staff and senior levels.

Said one senior agency executive, "committees tend to come and go at the highest level of government agencies. At the working level, the sense of mission is very strong, and cooperation flows out toward a common goal. This level wants to get the job done. They are not concerned about power. There may be posturing at the senior level, but at the working level cooperation is great."

Comments were similar in the Lower Green Bay RAP. One administrator mentioned that it was easier to speak with people in other agencies as a result of the RAP.

The assessment of intergovernmental cooperation was not as positive in Saginaw Bay for a number of reasons. One person reportedly would have liked to think there are new working relationships being forged, but simply didn't see it happening. As this person figuratively put it, "the seeds sown have been too few, too widely dispersed, and not sufficiently fertilized." Another official doubted that an enhanced intergovernmental partnership would result from the Saginaw Bay RAP. This official pointed out the incongruity of the state wanting localities to be more involved in policy making in the face of shrinking state and local budgets.

Tensions

Not surprisingly, participants in all three RAPs reported lingering resistance to ecosystem management and intergovernmental cooperation. Perhaps the most critical tension revolved around the question of meshing narrow agency mandates with the broad aims of ecosystem management.

The Hamilton Harbour experience was instructive. Some agency representatives argued that water quality should be the major focus of the RAP. As one official said, "it is important to remember that the Great Lakes Water Quality Agreement is the reference for this undertaking—water issues should dominate the decision making process." Conversely, some argued that it was exactly this narrow perspective which had led to the current need for remediation. Thus, representatives from academic institutions, public interests, consultants, and some government representatives suggested that from an ecosystem perspective, the natural resource concerns of the entire Hamilton Harbour drainage basin (including land use) should motivate RAP recommendations.

The tension between the broad scope of the ecosystem approach and the more narrow agency mandate was understandable. Agencies wishing to participate in the RAP process felt constrained to those specific areas where their organizational mandate fit the RAP. Likewise, they were more comfortable operating in their traditional roles. Moving the process "off the water and onto the land where problems originate met with tremendous resistance," observed one research scientist.

Turf protection became most evident during discussions about which agency should take responsibility for implementing portions of the RAP. In this case, agencies wanted to protect their authority but were reluctant to take on RAP responsibilities. Said one person, "[Turf protection] is not overriding, but it is inevitably present as an undercurrent in these discussions." This individual further qualified these comments, saying that because of the RAP process, "people sit down together. They are compelled to listen, interact, and address problems. Cross fertilization occurs. The barriers become more porous as a result of interactions."

Observations

Clearly, the ecosystem approach is taking hold in a highly complex institutional arena. Many agencies have their own on-going interests and commitments which don't stop because of a shifting emphasis to ecosystem management, no matter how noble its policy aims. Even so, the RAP has provided an opportunity for movement toward coordinated resource management at the "problemshed" level. In the final analysis, the comment of one provincial official is insightful. "It's too much to expect RAPs to capture all the attendant issues. Instead, the RAP, using the ecosystem approach, is doing what is possible to bring amenable agencies together." While there is vast room for improvements in the level of intergovernmental coordination, the RAP initiative has clearly made a significant step in this direction.

Ecosystem Management and Endangered Species Conservation

There are a number of reasons to be optimistic about the implementation of a policy promoting ecosystem management and the conservation of endangered species. First, as reflected in the principles above, the pursuit of ecological integrity is among the highest priorities of ecosystem management. Despite continuing debate over the definition of "ecological integrity", most commentators on ecosystem management would agree that the conservation of endangered species fits easily within those priorities.

Second, the utilization of the ecosystem approach entails management according to natural resources boundaries. It has been convincingly documented that the protection of habitat is imperative to the conservation of endangered species. Thus, the adoption of an ecosystem approach facilitates the most critical link in species conservation.

Finally, in the immediate future, the conservation of endangered species need not necessitate wholesale adoption and implementation of an ecosystem management policy at all levels of government. In fact, since ecosystem management is still an emerging technique, the implementation of ecosystem management principles on a species-specific case may be prudent in the short term. Under such a scenario, the creation of ecosystem management teams reflecting an appropriate balance of agency perspectives and disciplinary training may prove superior in terms of intergovernmental flexibility and institutional support.

In fact, institutional action along these lines can be observed at both the federal and state levels of government in the United States. In the Great Lakes region, the Wisconsin Department of Natural Resources is organizing small ecosystem management teams to address these sorts of issues. The Region 1 Office of the Environmental Protection Agency has also made a commitment to shift its institutional framework to better reflect present day ecological knowledge.

Conclusions

Once the ecosystem approach is adopted in principle, the need to coordinate strategies to manage the resource base across agencies becomes self-evident. Thus, the holistic perspective of the ecosystem approach provides a template for coordination and communication across levels of government. In doing so, the ecosystem approach motivates an intergovernmental discussion of the action agenda in resource management, helping to define program priorities, and increasing the consistency of resource management across agencies.

As one senior federal official in Canada observed, "We must find ways to encourage agencies to participate in ecosystem management without them feeling too threatened by the changes in the status quo. It is necessary to balance the need to make great strides forward toward institutionalizing the ecosystem approach and moving so fast that agencies put up barriers or sputter out on you. Matching the elegance of the ecosystem approach with institutional practicality requires a carrot and stick approach."

Thus in principle, the ecosystem approach has great potential for the management of all natural resources, including endangered species. Achieving broad based institutional support for ecosystem management will clearly take an investment of time and money, especially in those institutions where barriers are high. To many professionals in natural resource management, it is equally clear that despite these institutional complexities, the ecosystem approach is the most promising direction in which natural resource policy can move.

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Biodiversity, BioParks, and Saving Ecosystems

by

Michael H. Robinson

In the course of their development museums have clearly undergone an evolution that converges on the one hand with universities and the other with zoological and botanical gardens.... What a splendid institution it would be that combined under one well-coordinated management and on one tract of land university, museum, and gardens–botanical gardens and real zoological gardens–not merely gardens of nothing but vertebrate zoology.

-Frank Lutz, addressing the American Association of Museums, 1930.

Introduction

For nearly twenty years I was that most fortunate of all field biologists, one lucky enough to be based in the humid tropics. Compounding my serendipitous good fortune, an oxymoron no doubt, was the opportunity to travel the biological paradises of the world, including the island of Serendip or Ceylon. Ultimately, by the time I reached Washington D.C., I had carried out research in more than twenty different tropical countries. The overwhelming message of these adventures was contained in the impact to eye, ear, nose and brain of stunning biological riches.

The tropics are truly the Fort Knox of biology, or its Louvre, Prado, or Hermitage. There seems to be little doubt, even if we halve the species estimates of Erwin (1982, 1983a, 1983b), or even more drastically reduce those of Erlich & Wilson (1991), that at least 90% of all terrestrial species occur in the tropics. This is life profligate in forms, specializations and complexity. The extraordinary adaptive specializations found in all tropical organisms represent evolutionary fine tuning and coadaptation on a vast scale.

This biodiversity, stunning as it is, has hardly been explored by science. The world investment in tropical biology is a tiny amount in comparison to the unexplored biological riches. In fact the world distribution of biologists is inversely proportional to the world distribution of species. Striking evidence of this is cited by Myers (1987). He has pointed out that Colombia; with at least 30,000 plant species, has about a dozen botanists capable of determining new species, whereas Britain, with 1300 plant species, has 1400 botanists.

Whatever we conclude about the complexity of tropical biology we can be certain that there are numerous plants and animals throughout the region that have an as yet undiscovered potential for human use. The very nature of the evolutionary struggle between organisms in these species-rich environments means that they have evolved an amazing range of weapons of attack and defense; weapons that we can exploit in pharmaceuticals, insecticides, fungicides, herbicides and the like.

In addition, throughout the tropical world there are undoubtedly plants and animals that can add to our limited domestic stocks. The species richness has to be represented by overwhelming genetic diversity that we can exploit in bioengineering. Wilson (1992, Chapter 13) discusses and describes these *Unmined Riches* comprehensively and brilliantly.

This biodiversity is in peril as human populations in the Third World undergo explosive growth, and economic development there follows the same destructive pattern that it did during the Industrial Revolution in the developed world. Ours is a century of massive change, particularly in its second half. The world population has increased by 3 times, our economy by 29 times and our use of the primary productivity of the planet now approximates to 40%. All this has exerted enormous destructive pressures on the remaining unchanged habitats which at mid-century were predominantly located in the tropics. Myers (1990) has estimated that the rate of destruction of rainforest in 1989 represented an increase of 90% compared to 1979. Clearly the world's biodiversity will continue to be in dire peril.

What Can Be Done?

Individual endangered species can be saved by both *in situ* and *ex situ* breeding programs (review by Conway 1986). These can involve all the innovative genius of science and technology, and all the art of animal husbandry. They can be inspiring, exciting and of enormous value in focussing attention on the biological *fin de siecle* crisis. But what is at risk are entire systems of interdependent and interlinked species, both of plants and animals. These cannot be saved by breeding programs despite the plausible arguments (Mallinson 1991) about keystone species that can carry whole systems. The magnitude of the problem is too great for these measures, in the end we have to save ecosystems.

The separation of the exhibition of living animals in zoos, and living plants in botanic gardens, is an anomaly and an anachronism...

The conflict between development and population growth on the one hand, and the maintenance of biodiversity on the other, can only be solved by political measures, globally. Arguments that somehow a new code of bioethics could solve these problems seem to me to be delusional and unrealistic.

The BioPark involves combining the attractiveness of living plants and animals with exhibitry that explains their structure, physiology, history and interconnectedness

There are some techniques available that could guide the politicians. Some deal with the large scale, some with the small. Examples are contained in the volume resulting from the National Academy of Sciences/ Smithsonian Institution forum, on Biodiversity (Wilson 1988) and others (e.g., Rubinoff 1983; Wilson 1992; Gradwohl & Greenberg 1988).

In essence all the large scale proposals for saving life on earth call for either a slowing of the pace of destruction, or a moratorium on it. The long range purpose of such a moratorium is frequently not articulated as clearly as the short-term reasons for it. But almost always it is seen, dimly or clearly, as a means of buying time to do the research necessary to find 'alternatives to destruction'.

This logical progression, from the idea of slowing or halting the present destruction, to that of finding development methods consistent with the preservation of biodiversity, begs the crucial question: How do we secure the adoption and implementation of such policies? I believe that only if the developed world provides major financial support for Third World habitat conservation can time be bought for the research into alternatives. And here *is* something susceptible to the effects of education. In this case, I believe, education can result in public pressures on the governments of the economically advanced countries. They alone can provide the resources necessary to solve the day-to-day problems of urgent necessity that afflict the tropical world.

Here is where I believe that bioexhibits (a useful neologism for those public institutions that exhibit aspects of biology) in the developed world have a central role to play in such an education of public opinion. Zoos, Aquariums, Botanic Gardens and Natural History Museums can all be frontline forces in the struggle for the future of life on earth. To do this they will need to make rapid progress with programs in public education, and in many cases upgrade their exhibits.

My own view is that these institutions need to become more holistic, more integrated and much more innovative (for a contemporary analysis, see Carpenter 1992). The separation of the exhibition of living animals in zoos, and living plants in botanic gardens, is an anomaly and an anachronism, originating deep in history in the disparate origins of the two institutions.

BioParks and Biodiversity

I believe that most of the major problems facing the planet can only be solved if we have a biologically enlightened population. This may seem like the re-emergence of the enlightenment fallacy, but it is not. Biological literacy is a precondition for sound decision-making in the last days of this century, and in the next.

Of course, this assumes the survival of widespread democracy, and the corollary existence of governments that are susceptible to public pressures and have some freedom of choice in major policy decisions. This may be a pipedream if populations increase beyond their present tinder-box densities. Formal biological education seems to me as essential to our future as Latin, Greek and Theology were once considered to be in medieval times.

But non-academic, informal, popular biological education may be even more important. To achieve this I think we can capitalize on the powerful fascination that living plants and animals hold for nearly all humans. If statistics on pets and houseplants are any indicator, we all have an urgent need for contacts with other living things. In an urbanized society, zoos, aquariums, parks and gardens may be the only remaining places where such contacts can be made for the majority of people.

Despite the extraordinarily high quality of natural history, wildlife and science programs, television's two-dimensional, diminished images do not really substitute for the fascination of 'real' living plants and animals. At least 115 million people visit zoos and aquariums in the United States every year. Equally impressive is a recent survey on environmental issues made in the US by Peter D. Hart Research Associates, for WWF USA. It involved a telephone survey of 880 youth age 11 to 18, and 411 parents. Eighty-two percent of the young people in this survey had visited a zoo, and 65% an aquarium, in the two or three years before the survey. Sixty two percent of the youth had visited a natural history museum in the same period. In all, 93% of the sample had visited a bioexhibit in that time. Furthermore, new zoos and aquariums continue to open, and attract visitors, despite the omnipresence of television. Exploiting the potential of these resources for attitude-changing bioenvironmental education places a tremendous responsibility on us all.

The concept of the BioPark is foreshadowed by Frank Lutz (1930) in the quotation at the head of this paper. The basic ideas were reiterated under the descriptor *Biological Centre*, by Boyden (1969) in a very perceptive article that fell on deaf ears. I convergently developed the idea, unaware of its distinguished precursors, in 1986. It was a natural outcome of the Smithsonian experience to think of interconnecting the disparate elements of life sciences that are presently separated by institutions. That is the essence of the idea.

The BioPark involves combining

the attractiveness of living plants and animals with exhibits that explains their structure, physiology, history and interconnectedness. It is composed of subject matter from existing institutions, such as: museums of natural history, anthropology, art; botanical gardens and arboreta; and zoos and aquariums. As such, a BioPark combines not only the subdisciplines of biology (i.e., botany, zoology, genetics, and ecology), but also connects biology to other academic disciplines (i.e., medicine, geology, geography, social science, math, astronomy, archaeology, ethnology, and paleontology). Figure 1 shows the connections between the BioPark and the living world. The way the BioPark would work is best explained by examples. My favorite example (and fantasy) is building a pollination exhibit.

BioPark Exhibit 1: Pollination

This is an exhibit that could be developed very easily in a botanic garden as an adaptation of a small greenhouse or conservatory, would require the construction of such at a zoo, and could be built in any natural history museum which had a well-lit gallery. The animals and plants can be kept together in a mutually harmonious setting.

The variety of available flowering plants is staggering, this is itself a part of the story. The physiognomy of the plants can be chosen to illustrate a range of growth forms. The plants can illustrate a wide range of colors, shapes and fragrances.

Flower structures can range from simple to very complex. Their animal pollinators include many kinds of insects that are relatively easy to culture. Butterflies provide an appropriate centerpiece of colorful activity. In addition, bumblebees and hummingbirds can be included to add to the activity and color; they are without excessively demanding husbandry requirements. As an aside, I should comment that few zoos, or botanic gardens, take advantage of their horticultural assets to combine beauty with the illustration of botanical principles. Flower-beds themselves can be pollination exhibits.

The pollination devices by which *animal-pollinated* terrestrial plants accomplish their sexual ends are among the most complex known to science. Flowers scented, brightly colored, conspicuous, beautiful, wondrous and delightful, are the lures that plants produce in order to accomplish the transfer of their gametes. They are the conspicuous manifestation of the sex life of a very substantial number of plant species. The pollination relationship between plants and animals is one of the most intricate and intimate of such interactions that we can exhibit. It is a perfect vehicle for BioPark holism. Properly developed it can highlight, in no particular order of importance, the following topics.

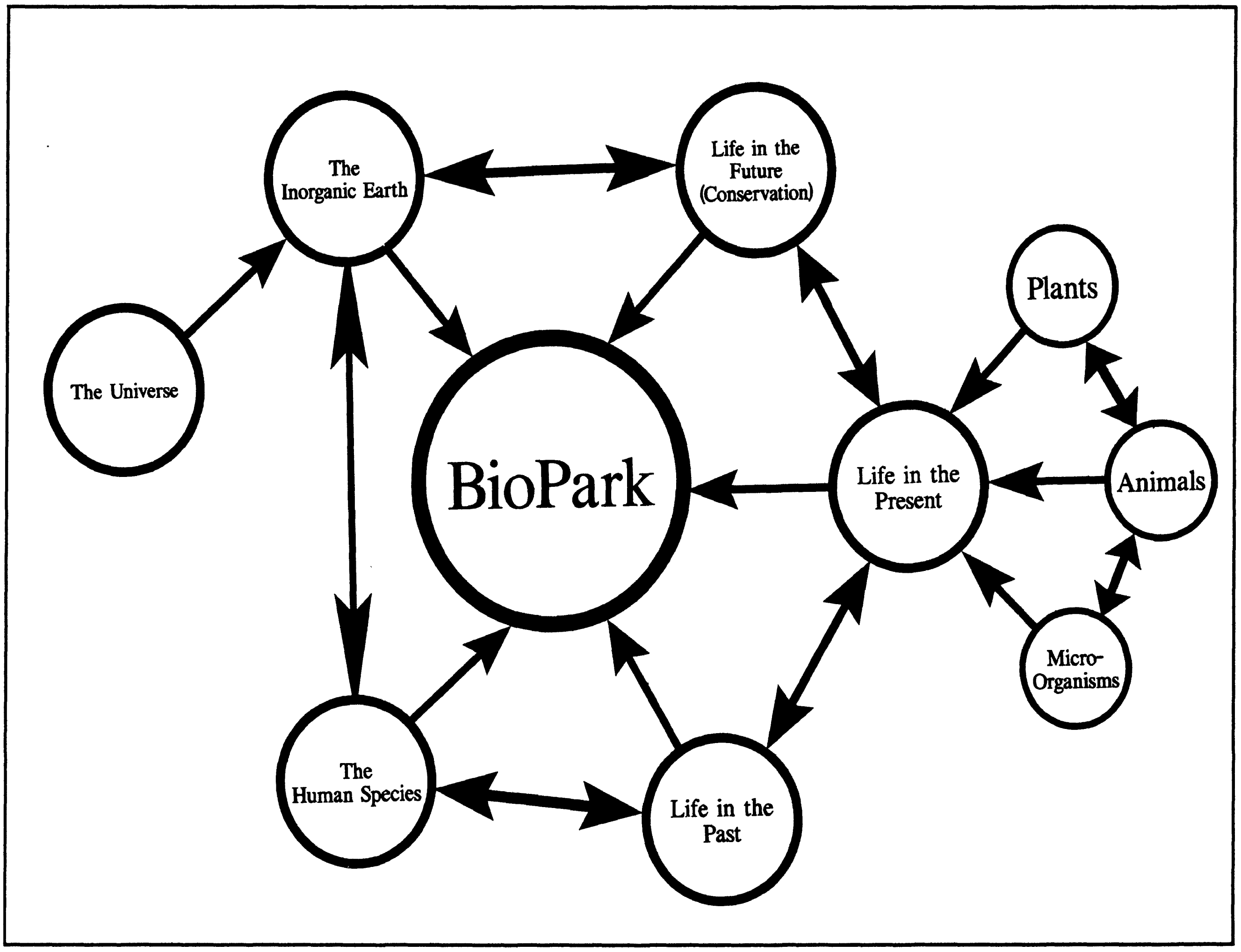

Figure 1. Relationship of the BioPark to the world at large.

Flowers and their mechanisms of pollination. This is an outstanding example of evolutionary diversity. They are among the most finely tuned coadaptations known. The range extends from the simple cup-like actinomorphic flowers to the complex zygomorphic orchids. Flowers are diverse in the lures they use to attract pollinators, and the devices that ensure the transfer of pollen and, frequently, cross-pollination. These devices can best be illustrated by using large three-dimensional working models rather than video displays. Some of the flower models should be large enough for children to enter and play the part of pollinators. (Perhaps even with appropriate bee suits and wings.)

The specializations of pollinating animals. These, which are anatomical, physiological and behavioral, can also be presented in dramatic ways. Models of butterflies, hummingbirds and bees of various kinds are more engaging than diagrams. Size is important; a four foot long model of a bee would reveal more of the structure of pollen brushes, pollen baskets, eyes, mandibles, proboscis, and wings than a four inch model. The visitor could feel the hollow of the tibial pollen basket and touch the animal's 'furry' surface. The model could show the insect's internal organs. Models of heads and mouthparts of nectar-feeding animals can be made interactive: the butterfly's large coiled proboscis could be made to uncoil and even be aimed to probe an adjacent cutaway model flower. Modelling the differences between the nectar-collecting structures of butterflies, bees, flies, hummingbirds, bats and opossums would allow them to be compared, seen, felt and closely examined.

The energetics of flight. The bee fuels itself with nectar; this makes a comparison with gasoline-powered machines simple and direct. What is the EPA mileage of a bumblebee? How far can it fly between one flower (fuel pump) and the next, before its tank runs dry? Visits to flowers by bees could be compared to pit stops in a motor race. Fortunately the kinds of data that we need to back-up this exhibit have been worked out in recent careful research (Heinrich 1979). A comparison of flight in animals and airplanes would add greatly to this exhibit.

Differences in the perceptual worlds of animals. This is an important biological and philosophical point. The visual spectrum of insects differs from ours and they can see into the near ultraviolet. The connection with pollination is simple and direct. Flowers are colored and insects see color. This is a special case because the insects see colors that we do not see and flowers have patterns in such colors that are invisible to us.

The insect-eye view of nature can now be simulated by simple adaptation of a color video camera. The visitor can thus see flowers as a bee or butterfly might see them, and see patterns and markings invisible to the unaided mammalian eye. The flowers in the exhibit could be scanned for their 'secret' colors. This makes the very important point that *our* perceptual world is only one out of many. The differences between the spectral sensitivity of insects and vertebrate pollinators is highlighted by the differences in color between the insect pollinated flowers and the hummingbird flowers. Even more extraordinary than ultraviolet vision is the ability of bees, and some other animals, to use the plane polarization of light to locate the sun's position and orient themselves when the sun is invisible. Bees also have a very accurate clock.

Odors can also make their point. Fly-pollinated flowers have capitalized on the attraction that rotting meats have as nursery sites for many fly species. Unlike the flowers scented to attract butterflies, moths, bees and wasps, those directed at flies have smells that are distinctively unpleasant even to our poorly developed olfactory senses.

Research about pollination and pollinators. Research is surely part of the BioPark story. The explanation of science and its aims and methods is significant part of the education that will be needed if the problems now facing humankind are to be solved. This is particularly true at a time when anti-intellectual attitudes are particularly widespread and on the increase.

In explaining scientific research details of process can excite and inspire. The simple story of how Karl von Frisch (1953) investigated color vision, orientation and communication in bees and the fascinating details of his experiments on the communication 'dances' of bees are good material for this. An observation hive, set up within the pollination exhibit but connected to the outside world (so that the bees are not working within a confined space and harassing the visitor) would provide a reference point for explications of the methods and results of bee research.

The implications of the pollination relationship for humans. Honey was the first source of sweetness for many cultures. The bee is represented in Egyptian hieroglyphics and there are references to honey in poetry, religious texts and many early writings. A specific hunger for sweet substances probably lies at the base of our addiction to sugar, the enormous industry that this now supports, and the health problems that are a consequence of truly 'unnatural' levels of sugar in our diets.

Honeybees are one of the few insects managed on a large scale by humans and can be regarded as semi-domestic. Bees figure in art from an early stage and bee-hives are prominent in medieval art. This aspect of our relationship with a pollinator could be appropriately exhibited. Hummingbirds, restricted to the New World, impressed early humans since the lines of Nazca in Peru which feature what is clearly a hummingbird. This outline has a wingspan of more than two hundred feet. Butterflies and other insects also figure in art the world over.

Flowers probably have an even more pervasive cultural spread. By outrageous chance they somehow move us to delight. Our perception of their form and color has accorded with our esthetic predispositions and they evoke feelings of pleasure. This happens despite the fact that evolution 'designed' them to please animals radically different from ourselves. It is amazing that what might be called the embellishments of the sex organs of plants acquire beauty in our minds. Their odors, again not the evolutionary outcome of selection to please mammals, somehow titillate our noses.

Our history with respect to flowers is almost incredible. We have refined plant odors since early historical times and adorned ourselves with them. There are fragrance industries based on floral perfumes ranging from the temperate regions to the tropics, and from Devon Violets, through Attar of Roses, to the overpowering Elang Elang of Madagascar and the Comoros. We have cultivated flowers to the point of extreme genetic modification and selected the most bizarre colors, shapes and habits to produce a non-utilitarian plant industry of huge proportions and considerable economic significance. We mark our courtships, love affairs, marriages, birthdates, and deaths with floral tributes and flowers figure significantly in art, poetry, literature and songs. This is an immense subject with which we can expand the scope of the pollinarium.

The function and mechanisms of sex. Most zoo exhibits are based on vertebrates, where sex is a *relatively* simple matter. We seldom present any views of the function and mechanisms of sex that depart from the vertebrate model. In the pollinarium we can and must explain the diversity of sexual mechanisms in plants and the unusual sex determination system of bees. Sex in invertebrates has many variations on 'standard' themes, particularly compared to vertebrates. Zoos should do more to explain the mechanics of vertebrate sex and not merely allow it to be the subject of tittering and ribald remarks. But invertebrates are surely the basis for a biological *Kama Sutra.* Copulation in bees at the end of a kind of marathon survival flight is a phenomenon worthy of Homer.

The evolutionary history of this intimate relationship between plants and animals is complex and worth discussing, we can exhibit primitive flowers and primitive flower-visiting animals.

Geography is another subject that can be linked to pollination. Many Chinese zoos have a world map at the entrance showing the distribution of the animals in their collection. This simple device could be followed in the pollinarium to show the origins of the flowers, insects and birds.

There are obvious segues into other subjects: physics, mathematics, chemistry and onwards. Perhaps the final message given to the parting visitor could be based on Darwin's (1859) illustration of ecological interconnectedness: "The number of bumble-bees in any district depends in a great measure on the number of field-mice that destroy their combs and nests....Now the number of mice is largely dependent, as everyone knows, on the number of cats....Hence it is quite credible that the presence of the feline animal in large numbers might determine, through the intervention first of mice, and then of bees, the frequency of certain flowers."

BioPark Exhibit 2: Giants

Most zoos have Elephant Houses, usually consisting of a massive building built to railroad station architectural standards and dimensions, with a grand hall at its center. Hippos, rhinos, giraffes and elephants are frequently the focus of attraction. This can be used for a relatively low cost *bioparkisation* of an existing zoo exhibit. The exhibit program is to use the impressively large animals as a center from which to expand outwards to as many aspects of biology and other related subjects as is logistically possible. Here is a description of an actual conversion of an existing traditional exhibit at the National Zoological Park, Washington, D.C.

It has always seemed regrettable to me that one could be awed by the sheer splendor of a live elephant and not be able to see, nearby a skeleton of the creature, or know how its brain compared with that of a human, or how its marvellous trunk works. Since we clearly could not afford to buy skeletons we opted for models, and decided on cut-out models rather than sculpted ones. We have life-sized three-dimensional, models of an African elephant and a *Megatherium.* These serve several purposes. One side of the elephant model shows its skeletal structure, its heart and brain. Nearby is a cut-out of a human showing the same structures, and close to this are elephant and human skulls, cut down the midline to show the cranial cavities, teeth and other parts. One can look from a living elephant to the structures that support it, and compare them with human structures. At the front end there is a manipulable model trunk, with which to pick up peanuts, and at the rear an exhibit on urine and feces.

The *Megatherium* model is huge and highlights the complex evolution of the elephant family. It shows the *airs*

Great Indian rhinoceros *(Rhinoceros unicornis)* on exhibit outside the Elephant House at the National Zoological Park. Photo by Jessie Cohn, National Zoological Park.

Visitors to the Elephant House can learn about the rhinoceros' role in its ecosystem through information on interpretive panels such as this. Photo by Jessie Cohn, National Zoological Park.

and variations on a theme that they played on teeth (the tusks are on the lower jaw and curve down). We also have a reconstructed *Megatherium* skull on exhibit. Displayed close to the elephant models are exhibits on the endangerment of present-day elephants, on their conservation, on elephants in human history (mammoth's tusks in neolithic settlements), and the food intake of elephants. In the same area we have a realistic life-sized model of a *Tyrannosaurus*, setting the scene for a comparison between mammalian and reptilian giants. We deal with size, large and small, in living organisms in a graphic on one side of the *Megatherium*. This ranges from redwoods and giant kelp to tiny insects.

A model rhinoceros is used to tell the same stories about structure and function, including the mutualistic relationship between tick birds *(Buphagus africanus)* and the African rhinoceros *(Diceros bicornis)*. Finally we will grow trees *(Trewia nudifolia)* inside the exhibit that are from seeds dispersed by rhinos. Rhinos eat the fruits, and the undigested seeds pass through the intestine and are excreted with the feces. Rhinos defecate in "latrines", and clumps of *Trewia* trees grow from these. A further expansion of this engagingly holistic experience would be to show the complex relationships involved in the utilization of elephant and rhino dung by scarab beetles. In East Africa a succession of different species of scarabs colonize the dung as it goes through a temporal progression from fresh to mature. Scarabs figured prominently in hieroglyphics, art, and other aspects of ancient Egyptian culture.

Conclusion

This brief outline of how bioexhibits can be expanded into holistic, informal, broadly synoptic educational entities is necessarily incomplete. It expresses a concept rather than a blueprint. I hope that it is provocative and therefore can lead to brainstorming among those dedicated to conservation and the preservation of biodiversity. Further provocations can be found in the bibliography. Somehow, if our future is to contain biological richness, we have to capture the spirit of Lutz (1930). He was right about building *splendid institutions*; surely now more than ever we need that experiential richness to match what we are destroying and inspire us to stop the destruction?

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Ecosystem Education

by

Karen J. Schmidt

We know that intact ecosystems ultimately will not be saved by developing and implementing one species recovery plan at a time, by fencing off ecosystem fragments in protected areas and ignoring what transpires beyond their borders, or by depositing a few representative plants and animals in zoos or aquaria. It is likewise true that neither the value of ecosystems nor a love of nature can be learned from scrutinizing plants and animals one by one in a laboratory, classroom or textbook.

Ecosystem-based education strives to...reconnect individuals with their ecological residences

But today, in a country composed largely of city dwellers and suburbanites, few people are taught even to see the natural system outside their doors, let alone to appreciate its beauty and complexity and to understand its irreplaceable and increasingly damaged life-support functions. An educational system that rectifies this ecological illiteracy and fosters a reverence for nature is a necessary precondition for successful ecosystem-based approaches to species conservation—necessary to generate both a committed public and a new cadre of holistically-minded conservation professionals. Just as taking an ecosystem-based approach may be the key to preserving species, so too it may be the key to unlocking the mechanistic and reductionist view of the natural world perpetuated by conventional life science curricula.

In 1989, the Northern Rockies Conservation Cooperative (NRCC) in Jackson, Wyoming, set out to develop a model for incorporating such an ecosystem approach into life science education. The resulting curriculum guide (Schmidt 1991) was designed specifically for high school biology students and teachers. However, as we learned from grade school teachers, college professors, environmental educators, education specialists in government agencies, and others who used the curriculum, an ecosystem approach is adaptable for, and appeals to, almost any audience and age level.

Three closely related factors characterize the ecosystem approach taken by NRCC and distinguish this approach from that of conventional life science curricula: (1) a focus on a specific, local, ecologically defined area, i.e., the Greater Yellowstone Ecosystem (GYE); (2) an emphasis on processes and functions that generate and maintain biodiversity at both the population and community level, rather than on the physiology and life histories of species or classes of organisms; (3) the treatment of human populations and activities throughout as integral ecosystem components that both shape and are shaped by their environment.

How each of these key characteristics contributes to the success of an ecosystem-based approach to conservation education is discussed below.

Ecosystem As Home

Ecosystem-based education strives to diminish people's detachment from the natural world, to reconnect individuals with their ecological residences. The easiest and most important way to establish this connection is to engage students in direct experience and careful examination of their immediate surroundings.

This means that, in its Yellowstone curriculum, NRCC targeted as its primary audience teachers and students in Idaho, Montana and Wyoming who live in and around the Greater Yellowstone Ecosystem, who can go outside and see it, hear it, smell it and feel it. While we have been delighted to hear from teachers as physically and ecologically remote as New York City whose students are studying the GYE, we have been even more pleased to hear from teachers who are using our curriculum as a model for developing materials to study their own ecosystems. Getting out into the field and becoming intimately acquainted with the plants and animals in one's own neighborhood establishes a sense of kinship, of belonging to the natural world, that any number of nature videos—or, for that matter, frog dissections—cannot impart.

One lesson in NRCC's curriculum, for example, has students conduct inventories of the plants and animals in the field on a variety of local plots. The exercise can be conducted in a national park or in an urban schoolyard; what matters is that it takes students physically and mentally out of the classroom and into the ecosystem around them, whether it be intensively managed or nearly pristine.

Map studies are another invaluable tool. A series of maps depicting present (and past, if available) geomorphology, hydrology, community types, species distributions and so forth can be used to supplement on-the-ground explorations to give students a sense of the overall scale of their ecosystem, the spatial relationships between ecosystem components and how these have changed over time. In the Yellowstone curriculum, a series of questions about such a set of maps guides students through an exploration of the relationships between physical and biological ecosystem components and between ecological boundaries and political ones. Students compare the different maps to arrive at their own definition of the GYE and create a map of its boundaries, an exercise which illustrates both the usefulness and the artificiality of human delineations of natural systems.

Real ecosystems are of course less tidy, more complex and therefore more difficult to study than the ones in textbooks. But it is only through firsthand experience that the ecosystem begins to appear on students' cognitive maps of "home," that students begin to care about, and develop an ethic of caring for, their environment. Furthermore, the very "messiness" and subtlety of real ecosystems teaches humility_a commodity in regrettably short supply—about the limits of scientific knowledge and the inadequacy of technological efforts to replicate the complex ecosystem functions that are vital to human survival and biodiversity conservation.

Emphasizing Processes

Life science courses and textbooks typically are organized around a systematic survey of genetics, physiology and the evolutionary hierarchy of living things, culminating in a close inspection of human biology. Ecology is frequently relegated to a scant end unit that gets shaved even further to fit into the final week or two of a school year overcrowded with required course material. Even in environmental education programs where ecological interdependence is ostensibly the central theme, ecology often is treated in a simplistic or superficial way.

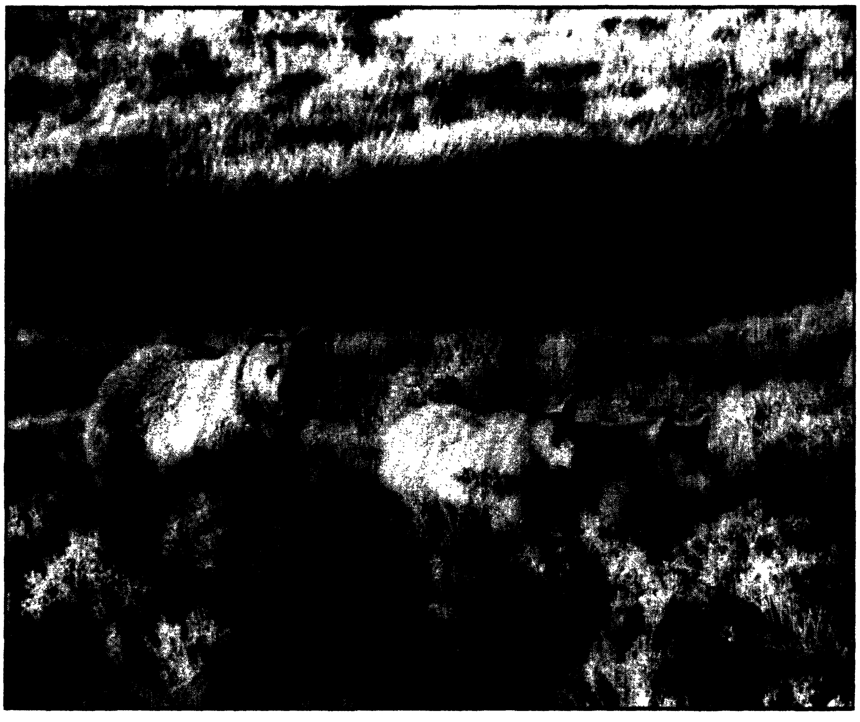
In contrast, ecosystem-based education takes the global and local ecosystems as the organizing principle for the study of life, and is informed by many of the sophisticated yet straightforward insights to be drawn from population biology and genetics, conservation biology, biogeography and related fields. Rather than focusing on species, it focuses primarily on the populations that make up communities and the ways in which the distribution, size and genetic diversity of those populations shift over time and in relationship to one another.

Teachers may be well-advised to take advantage of students' natural fascination with so-called "charismatic megafauna" to capture their attention. However, in ecosystem-based education, the study of lions or tigers or bears is a stepping stone, not an end in itself. For example, the NRCC curriculum uses a case study of the Yellowstone grizzly bear *(Ursus horribilus)* population to illustrate concepts of habitat fragmentation, population viability, small population dynamics and the extinction process. Students then use these concepts to uncover and describe the processes by which other, less visible populations have become threatened or endangered. Along the way, they consider the ecological, aesthetic or scientific values of those populations and develop arguments for their protection. They use island biogeography theory to predict the number of species likely to become extinct on a habitat patch in the ecosystem as it becomes isolated by human developments, and to predict which kinds of species will be most vulnerable.

An examination of community-level processes of natural disturbance and succession is critical to understanding how naturally dynamic patterns of biodiversity are and how human disturbances differ from natural processes in terms of their frequency, duration and scale of impact. One unit of NRCC's curriculum is devoted entirely to looking at fire as a key process that helps maintain the ecosystem's diversity and both enhances and threatens different aspects of the GYE that people value. As part of the unit, students compare the changes over time in community composition of stands of Yellowstone forests that have burned versus undisturbed stands and stands that have been logged.

Humans As Ecosystem Members

Whether students are conscious of it or not, their lives are, of course, intimately and inextricably interwoven into the fabric of the ecosystems they inhabit. They prey on some organisms and are parasitized by others. They take up and process nutrients, release wastes and eventually are themselves decomposed to provide nutrients for other organisms. Their survival depends on life-supporting ecosystem functions: soil generation and maintenance, amelioration of climates, maintenance of genetic diversity, waste decomposition, removal of toxins from water and air, and so



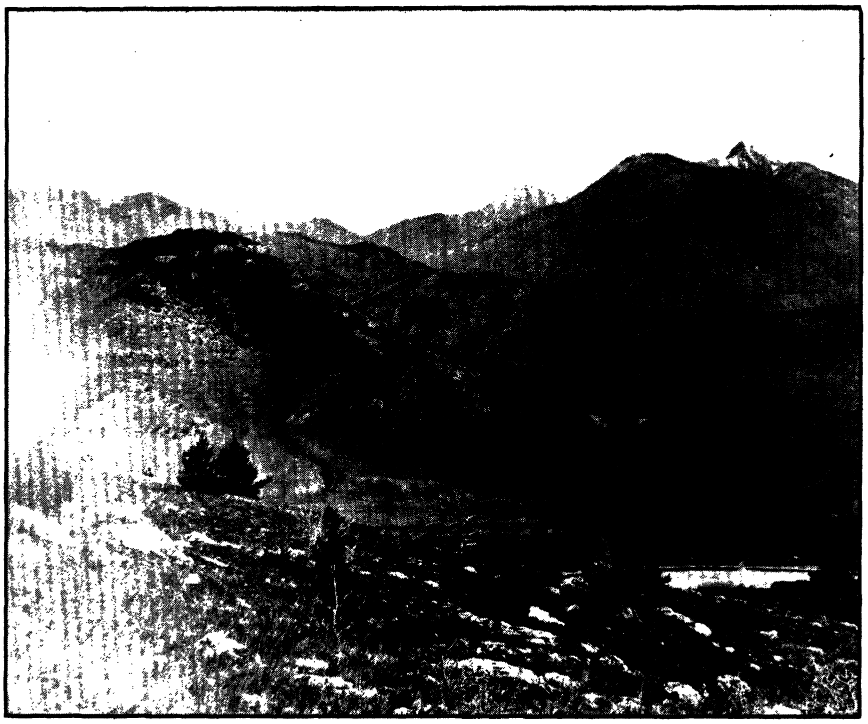
A female grizzly bear *(Ursus horribilus)* and her cubs within the Greater Yellowstone ecosystem. Photo by National Park Service.

forth. And their every action affects other ecosystem components, in ways that are magnified to global proportions by human technologies and numbers. It is perhaps the most important function of ecosystem-based education to engender in students a keen appreciation for these facts of life.

There are many ways to do this. At some schools, students have charted the flow of resources consumed and waste generated by the school's population, identified the attendant ecological impacts of those flows on local and distant ecosystems, and recommended and implemented measures to reduce those impacts (Orr 1989). In NRCC's curriculum, virtually every exercise includes consideration of both human and non-human factors at work in the GYE.

For example, analysis of the Yellowstone grizzly bear population includes an exercise in which students map the locations and causes of recent bear deaths and identify linkages between the evident geographic clusters of mortalities and the human policies and activities in those areas. Students compare maps of natural GYE features with maps of political boundaries and human constructs (e.g., towns, roads, dams, mines, ski areas, power lines) to explore the differences between political and ecological borders and the differential impacts on species and systems of contrasting land use practices and policies. In the field, students not only inventory local plants and animals but test hypotheses about the relationship between the intensity of human activity in an area and the number of native and non-native species found there.

Students also engage in role plays to experience the difficult task of balancing divergent local and national values and perspectives in making critical ecosystem management decisions. Should wolves be reintroduced? Should bison be protected when they wander onto private land? Should fires be suppressed? How can goals of job creation and economic growth be reconciled with ecosystem protection? The GYE lends itself particularly well to the examination of such questions, but similar ones are being asked every day in virtually every corner of the country.



A view from within Yellowstone National Park. Photo by National Park Service.

Finally, students identify the ecosystem's qualities that are most important to them and the actions they believe should be taken to protect those values. Some classes may actually submit their recommendations to policymakers and resource managers, or undertake their own conservation projects, such as setting up an ongoing monitoring system or developing an educational program for younger students.

From Ecosystem Education to Eco-Education System

Ecological considerations should have a place in virtually every discipline, not just the life science curricula—from English, history and economics to woodworking, health and driver education—just as ethical and cultural considerations must have a vital place in the science curriculum. But to be truly effective in promoting a working environmental ethic, ecosystem thinking cannot simply be tacked onto existing curricula; it must pervade and underpin them. Promoting stewardship and sustainable use of the biosphere must become as central to the purpose of our entire education system as is the development of a literate, skilled work force and an active citizenry.

In the meantime, it is incumbent upon conservation professionals in academia, government and the non-profit sector to promote the kinds of ecosystem-based approaches to conservation education described here, wherever and however they can. They can work to influence textbook design and adoption, help shape state and local curriculum guidelines, and contribute to the development of educational materials tailored to local circumstances. Perhaps most importantly, they can make themselves accessible to teachers and students and spend time in classrooms and in the field communicating their unique personal knowledge and love of the local environment.

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Karen Schmidt has created and lead several conservation education programs. She directed the Northern Rockies Conservation Cooperative's Yellowstone curriculum project and is currently an associate at the Environmental and Energy Study Institute in Washington, DC.

The Ecosystem Survival Plan: Zoo Visitors Save Wild Places

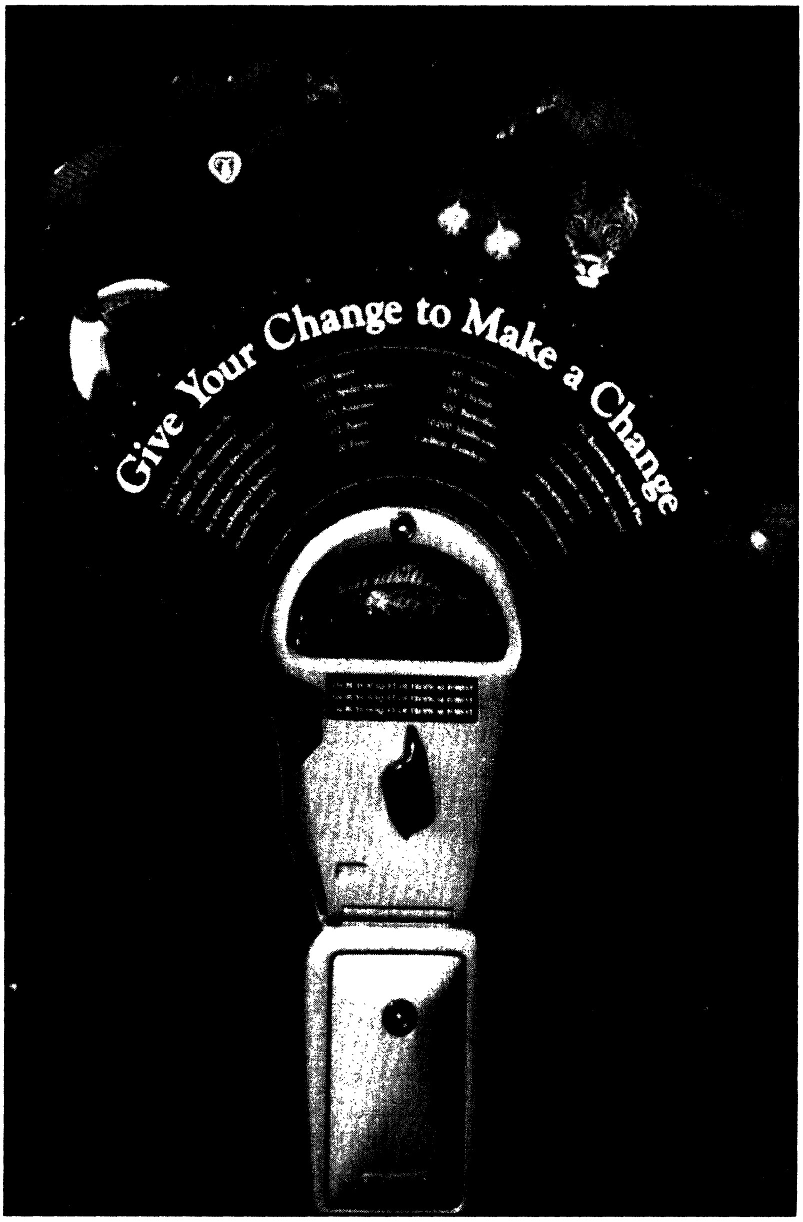
by

Norman Gershenz and Leslie Saul

Biologically rich habitats around the world are increasingly threatened by a great variety of human activities. The survival of thousands, perhaps millions, of species is at risk from extinction. The conservation strategies of zoos and aquariums are just now beginning to shift their 20 year old emphasis from *ex situ* single species conservation to the preservation of wildlife habitats; maintaining ecological and evolutionary processes.

Zoos, aquaria, and other scientific institutions have a critical role in the preservation of animals, plants and their complex ecosystems. In addition to the work of public education (both formal and informal), research, and captive breeding, zoological institutions have the unparalleled ability to provide an opportunity for action, and to reach 130 million people with the inspiring story of the diversity of life that inhabits the planet.

The roles that humans play both culturally and economically are key to creating solutions that will persist into the next century. Clearly, public institutions can play a critically important role by building a strong, well-informed and active constituency for nature. In addition, these institutions must motivate people to change patterns of behavior that significantly affect the fate of ecosystem survival.



The Conservation Parking Meter, now installed in 23 zoos, enables visitors to "see" how their donations help conserve rainforests. Photo by Norman Gershenz.

The Ecosystem Survival Plan

The Ecosystem Survival Plan (ESP) was founded in 1988 to unite zoos, aquaria, botanical gardens, natural history museums, and nature centers in concerted conservation action allowing these institutions to focus the attention of their millions of annual visitors on concrete, achievable conservation goals. The mission of the Ecosystem Survival Plan is to preserve plants, animals and natural communities by enabling the public to participate on many levels in halting environmental devastation through the preservation of wildlife and by the purchase of their threatened and endangered habitats.

The Ecosystem Survival Plan is made up of a consortium of zoological institutions in a unique partnership working in association with the American Association of Zoo Keepers and The Nature Conservancy. ESP forged an early partnership with The Nature Conservancy to take advantage of that organization's expertise in land purchase and protection. Rather than duplicate effort and splinter the funding available for conservation, ESP sought to build the broadest possible coalition of conservation organizations, private companies, and concerned individuals to amplify their efforts.

Public Participation to Protect Nature

ESP empowers the public to contribute directly to protection of threatened ecosystems through two grassroots fund-raising strategies: the Conservation Parking Meter and the Adopt-An-Acre program. Monies raised in these programs are donated to purchase land in designated areas, such as La Amistad Biosphere Reserve and Guanacaste National Park in Costa Rica, and in the Rio Bravo Conservation Area in Belize. Five new conservation sites have recently been selected to receive support from the Ecosystem Survival Plan.

Conservation Parking Meters. This is ESP's most visible program. An urban parking meter has been transformed into an interactive vehicle for turning back the clock on deforestation in the tropics. With each quarter deposited in the meter, a colorful enamel hummingbird flies across the meter's window indicating that 90 square feet of rainforest have just been saved. A lively tropical rainforest graphic surrounding the meter's crown explains that, for example, with every two and one-half acres acquired through the Ecosystem Survival Plan, we save 0.001 jaguar, 0.03 spider monkey, 20 toads, 200 orchids, and 500,000 raindrops. This design won the prestigious Graphics '92 International Design Award.

The Adopt-An-Acre program helps to protect areas like this rainforest in Costa Rica. Photo by Leslie Saul.

The first two Conservation Meters were installed in early 1991 at the San Francisco Zoological Gardens and the National Aquarium in Baltimore. These two meters alone raised $75,000 for ecosystem protection in their first year. Today, 23 zoos have installed Conservation Meters, and in addition, the Nature Company has installed 99 meters in each of its retail outlets throughout the United States.

Adopt-An-Acre. This program raises funds for habitat preservation by awarding educational honorary "deeds" for gifts toward land purchase and protection. The program has proved to be an inspiration to elementary school students and teachers throughout the country to become involved in this vital cause. To date, schools from 45 states have paired environmental education programs with fund-raising drives to help preserve the earth's biodiversity through the ESP program.

ESP's Growing Popularity

The ESP program has received national media coverage on television's ABC's "World News Tonight" and CNN, National Public Radio and in *Time*, *Life*, *Newsweek*, *Scholastic News*, and *Seventeen* magazines. The program has received two World Wildlife Fund Conservation Awards, The Nature Conservancy's International Award for Conservation, Congressional Recognition of Honor for Conservation, and the National Environmental Council Award for Environmental Achievement.

The Ecosystem Survival Plan's education and fund-raising programs have proved themselves to have tremendous popular appeal and hold immense potential for successful ecosystem protection, preserving precious biological diversity. Participation grew from six to 50 institutions in one year—ESP already has partners spanning the globe from Canada to Malta.

The Ecosystem Survival Plan catches the imagination of the public—be it families visiting the Zoo, children in the elementary school classrooms, or shoppers at the Nature Company stores—in a way that allows it to make an immediate and tangible contribution to preserving a critical natural resource. ESP can educate thousands more people about the desperate need to conserve the earth's biodiversity and, with their thousands of small, individual contributions, the Ecosystem Survival Plan can make a lasting difference in the ecological health of the planet. The future success lies in new broader based coalitions that partner professionals, corporations, staff, volunteers and children in a common goal.

Norman Gershenz is National Director, Ecosystem Survival Plan (ESP), and Zookeeper at the San Francisco Zoological Gardens, 1 Zoo Road, San Francisco, CA 94132. Leslie Saul is Curator of Insects at the San Francisco Zoological Gardens. For additional information on how you or your institution can participate in the Conservation Parking Meter or Adopt-An-Acre programs, contact ESP Director Norman Gershenz at (415) 753-7052.

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