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# Symposium on Ecological Restoration

## Proceedings of a Conference, March 1993

# Symposium on Ecological Restoration

**Chicago, Illinois**

**March 2–4, 1993**

**The Palmer House Hotel**

**PROCEEDINGS OF A CONFERENCE**

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*Office of Water*

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# *Foreword*

Past and present human activities have severely degraded and at times destroyed natural ecosystems, resulting in the destruction and fragmentation of critical habitats, the endangerment and extinction of species, and a loss of biological diversity. We must reverse or reduce these impacts if ecosystems are to be restored. But what is restoration? On the most basic level, restoration can be defined as a process that returns a damaged ecosystem to a previous natural condition by recreating both its structure and function. A successful restoration effort results in a natural, self-regulating system in harmony with the surrounding landscape and the environment as a whole.

The U.S. Environmental Protection Agency (EPA) is in the process of exploring opportunities to support and encourage ecological restoration activities. The Symposium on Ecological Restoration provided an avenue for managers and scientists at EPA, state and local governments, academic institutions, and private environmental organizations to begin to focus on the use of restoration techniques to address environmental problems. The symposium's primary goal was to provide an open forum for dialogue on the many policy and technical issues related to ecological restoration. However, the symposium also enabled participants to explore and debate the strengths and weaknesses of various existing restoration programs and techniques and opportunities for future restoration activities. In addition, participants were able to come together to brainstorm priorities for data collection, research, and management actions.

We hope that this proceedings will provide a useful overview of many of the issues surrounding ecological restoration. We would also like to take this opportunity to thank all of the presenters and participants in the symposium. Their insights and enthusiastic discussion helped to make the symposium a success.

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# The Importance of Ecological Restoration

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Fifty-seven years ago this spring, a little group of Civilian Conservation Corps enrollees walked out to an old horse pasture on the outskirts of Madison, Wisconsin, and began digging holes. In those holes they planted sod stolen from a patch of the old tall grass prairie that still survived on a steep hillside overlooking the Wisconsin River near Sauk City, about 20 miles away.

This was the beginning of the restoration of the John Curtis Prairie at the University of Wisconsin (UW) Arboretum—now regarded as the oldest restored ecosystem on the planet. For many years we at the Arboretum did not know what to make of this historic site—the Kitty Hawk, as it were, of ecological restoration. Only in recent years have we reflected on this odd little experiment and come to see it as an historic event—as important in its way as Thoreau's stay at Walden Pond, or John Muir's experience in the Sierra Nevada.

The Curtis Prairie, however, is not yet widely recognized because the importance of restoration itself is not yet fully appreciated. My purpose here is to offer a few thoughts on the importance of ecological restoration, based mostly on my experience as an editor working in this area and an observer of restoration at the University of Wisconsin-Madison Arboretum and, during the past few years, through my work with the Society for Ecological Restoration (SER).

## The Work of Ecological Restoration

What can we say about the importance, the significance, and the value of the work of ecological restoration?

This is a question environmentalists have not yet clearly answered. Ecological restoration has developed rather slowly as a craft and as a conser-

**Ecological restoration pioneers begin restoring prairie soil to its original state (1935).**

vation strategy, in part because ecologists and environmentalists have been uncertain about its value in achieving conservation goals. They have welcomed ecological restoration as a way of repairing environmental damage, but they have been concerned that it might be accepted as an alternative to preservation and used to undermine arguments for preservation. They have also been skeptical about the quality of restored ecosystems and about prospects for restoration on a scale large enough to be ecologically significant.

My contribution here is quite personal. It is based mostly on my reflections on restoration and my experience, not as a restorationist, but as an editor and observer of restoration—a restoration-watcher. Restoration has two kinds of value or benefit. One benefit, obviously, is for the landscape. The other is the people involved: the restorationist and those who merely observe the process—the audience. Most discussions and criticism of restoration have concentrated on the first—its value for the landscape—and have ignored the second. For this reason and because I think it is equally important, I will concentrate on the latter.

## Value to the Environment

The benefits of restoration to the environment are obvious: when successful, restoration leads to an upgrading or expansion of habitat for native species, and often to an increase in an area's native biodiversity. Questions remain, however, about the quality of restored ecosystems and about the feasibility of carrying out restoration on an ecologically significant scale—a scale large enough to provide habitat for animals such as bison, wolves, or grizzly bears, for example.

These are important issues. At the same time, we must recognize that restoration is not merely one option—an alternative to preservation—but ultimately is essential to conserve natural and historic ecosystems in areas influenced by human activities. Wherever we are, we influence these systems; so if we want to preserve them, we must compensate for our influence. That compensation is restoration.

Thus the future of the natural landscape depends on restoration, not as an *alternative* to preservation, but as a way of achieving it. However imperfect our restoration efforts may be, they will ultimately determine the quality of our "natural" landscapes. Our best, most "natural" natural landscapes—that is, those most like natural, historic, or classic landscapes such as coastal marshes or tall grass prairies—will be restored ones. We have learned this from our experience here on the prairies of the Midwest, and it points to a general principle of mutual dependence—of humans on nature, and of nature on humans—that ultimately holds everywhere.

## Value to the Restorationist—and to the "Audience"

Restoration is not only a process or technology. Like other processes carried out by humans, it is also an experience and an expressive act. Perhaps the best way to think of it is as a performing art.

**A restorationist gathers seed among the grasses on the Curtis Prairie.**

Restoration is a performing art that provides a way to change those who participate from outsiders into actual members of the land community. This is the greatest value of restoration because it strikes at the detachment and alienation from nature that are the real roots of most environmental problems.

Restoration, then, is a model for a healthy relationship between human beings and the rest of nature, and also as a kind of ritual for achieving this relationship. Several ideas related to this are summarized as follows:

- Restoration is a powerful technique for basic research—a way of raising questions and testing ideas about the ecosystems being restored. In 1987 I introduced the term "restoration (or synthetic) ecology" to refer to restoration carried out for this purpose. We can change an ecosystem without understanding it very well, but to change it *back*—to restore it—we must understand it well and understand our influence on it. Thus, restoration is a way to increase our understanding of the natural landscape and our relationship with it. This is a step toward our re-entry or re-inhabitation of the natural landscape.

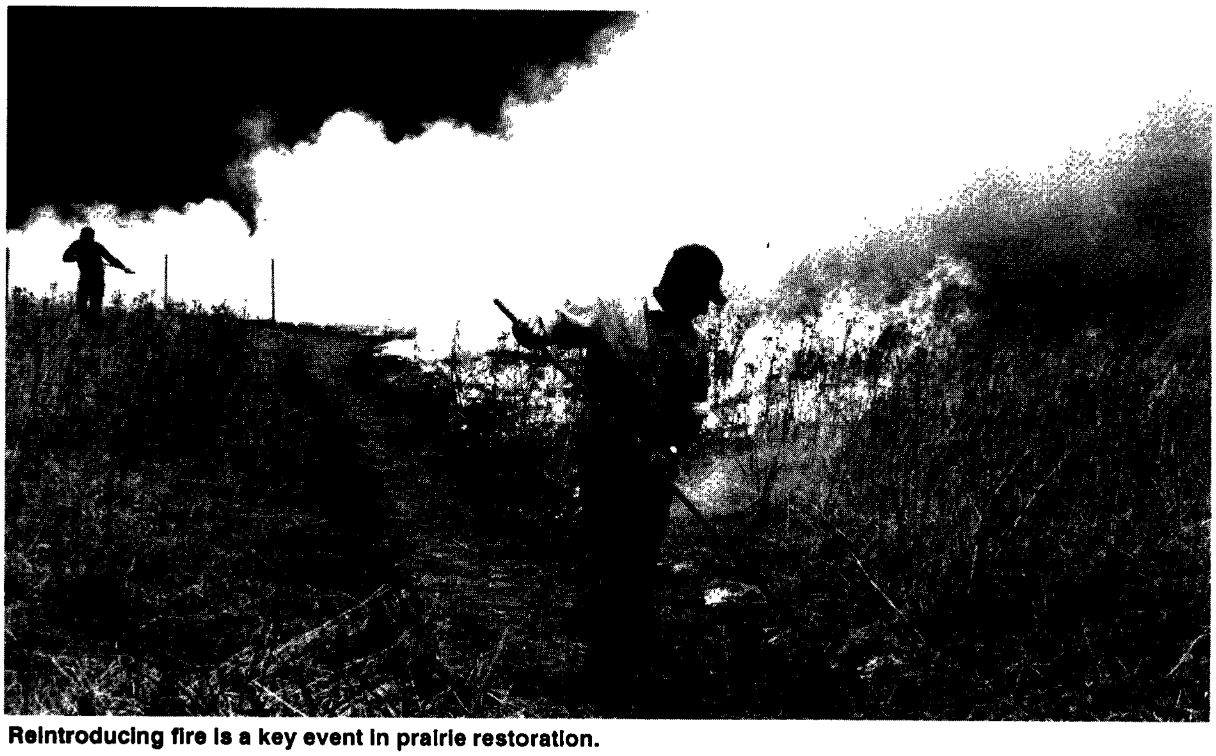
- For the same reason, restoration is a valuable way of teaching and learning about the natural environment and our relationship with it. Thus participation in local restoration projects now provides the basis for many school and public education programs. For example, the Earthkeeping program being developed by SER and the UW-Madison Arboretum provides opportunities for ordinary citizens to participate in restoration projects at selected sites to learn about and form a closer relationship with the natural environment. This program is partly based on the experience of restorationists like Steve Packard, Bob Betz, and others in the Chicago area. Their work serves as a model for this kind of environmentalism. We at the Arboretum and SER look forward to collaborating in its further development.

- Perhaps the broadest, most useful, and the certainly most *ecological* way to think about restoration is as an expressive act—a performing art—and the basis for a ritual or sacrament to deal with our relationship to the natural landscape. In fact, ecology is about relationships—that is, about each species registering on, or performing to, all the others.

This is a fruitful way of thinking about restoration. It has led to a number of ideas, most of which have been presented in my editorials in *Restoration & Management Notes* and which I will outline.

## Exploring Ecological History

First, as performance, restoration is a way of exploring a site's ecological history by reenacting or trying to reverse it. The key events in prairie restoration, for example, are reintroduction of species we have extirpated, attempts to exclude or reduce species we have introduced, and reintroduction of fire. When we do these things, we are not simply carrying out a task more or less successfully. We are also reenacting activities, such as the burning of the prairies in pre-contact times, that shaped the landscapes we are restor-



**Reintroducing fire is a key event in prairie restoration.**

ing. At the same time, we are trying to reverse the ecological effects of the reduction in fire frequency in this landscape since contact.

Several components of ecological wisdom emerge from this process. One is a greater awareness of the landscape and the history of our relationship. Another is a kind of ecological definition of who we are as a species, a society, a community, and an individual. And yet another is a clearer sense of the nature of ecological change—which changes can be reversed and which cannot.

Second, and closely related to the first value, is that restoration provides an opportunity for people to explore nature's classic human experiences by reenacting them. Thus, the restorationist enters the natural landscape as a gardener or farmer, a gatherer, at times a hunter, and sometimes a scientist. This also points to restoration's value as a way of achieving, through actual experience, a rich, satisfying relationship with nature involving a wide array of human interests and abilities.

Supporting this is a third observation—that restoration is closely related to rituals of world renewal, a major element of many indigenous cultures. What the Australian Aborigine or the California Indian did ritually to renew the world each year in the consciousness of the community, the restorationist does literally. What remains is to add the classic dimension of meaning and expression to the restoration process, making it, too, a ritual for renewing the world and achieving a healthy relationship with it.

**The restorationist enters the landscape as a gardener, a farmer, a gatherer, a hunter, and sometimes a scientist.**

**In a 1986 prairie restoration competition experiment, restorationists plant an old nursery at the McKay Center.**

## Exploring the Relationship between Nature and Culture

In a similar way, restoration has a close relationship to pastoral, the artistic exploration of the relationship between nature and culture. Not surprisingly, considering the frontier experience, pastoral themes are common in American writing and painting—classic examples are Mark Twain's *The Adventures of Huckleberry Finn,* or Thoreau's *Walden.* In both the protagonist withdraws from civilization to seek renewal through contact with nature.

The restorationist does the same thing in a different way. Rather than leaving civilization by moving across the landscape from the city to the countryside, he or she stays in the same place and attempts in effect to remove the city from the landscape to reconstitute "unspoiled" nature. This is a different way of carrying out the pastoral experiment. So, while restorationists have much to learn from pastoral art, they also have much to contribute.

Finally, we arrive at a single conception of restoration that synthesizes these ideas and observations:

- The relationship between humans and the rest of nature—like many other relationships, including those between the sexes or between species (predator and prey, for example)—involves problems that cannot be resolved in purely literal terms.
- Such problems can be resolved only in ritual terms, so that the relationship itself depends on suitable rituals.
- The work of ecological restoration provides an ideal basis for developing a tradition of rituals and public liturgies for negotiating and articulating a healthy relationship between the human community and the landscape it occupies.

These, then, are the main elements of the value of ecological restoration. It has value to the environment directly, and also indirectly, by affecting the restorationist and the community. It provides ways for both the individual and the community to reenter nature, to become working, "voting" members of the larger biotic community.

## Restoration's Critical Role

For all these reasons, I believe that restoration is not an activity of marginal value. It has a crucial role to play in conservation as the basis for a healthy relationship between ourselves and the rest of nature.

Two programs have emerged in part from the experience of restorationists in the Chicago area that reflect the previously outlined conception of restoration. The first is the Earthkeeping program being developed by SER and the UW-Madison Arboretum, which focuses on public education through restoration. The second initiative, the Earthkeeping Academy (EKA), has emerged during the past year in the course of planning for the first program. Its purpose will be to train field managers to conduct successful Earthkeeping projects. We believe that this experience can be so rewarding that, like the kids in the parable of Tom Sawyer painting the fence, people will actually pay to participate. In this way, the Earthkeeping projects will become self-supporting, and an inexorable force both for restoration and environmental education.

We think we can make this work. But we also know from experience that success will depend on field managers capable of making the most of the restoration experience. Such people are hard to come by—hence our plan for EKA. A detailed prospectus for the first EKA center plans to establish it in the Chicago area as part of the Chicago Wilderness program being developed by the Nature Conservancy. We are excited about this project and look forward to working with many local and regional organizations and agencies, including EPA, to carry it out. ❑

# *The Status of Restoration Science*

# The Status of Restoration Science
# Aquatic Ecosystems

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The Great Lakes mirror economic human behavior on the lands that surround them. Human behavior takes place primarily on the land, and thus the ecosystems of the Great Lakes are more than just the Great Lakes—they also include the surrounding land. To ask questions about the status of restoration science is to ask questions about how well we understand the behavior—structure and function—of ecosystems. This must necessarily include human presence and activities.

Because science is largely an attempt to create models of the real world—to approximate reality—we need to examine the models we use and ask about the utility of using models to restore an ecosystem. Traditionally, the scientific method has followed a reductionistic process—that is, the development of models of reality through a more refined understanding of the behavior of system parts. The underlying premise is that if we can understand the "workings" of the parts, an understanding of the whole will follow. While the reductionistic approach has been rewarding, it may be timely to now consider more holistic models to guide ecosystem restoration.

## More Art than Science

Restoration is at present more art than science. But scientists must determine the status of successful restoration to appropriately assess science's role in restoring ecosystems. When we discuss the restoration of ecosystems, questions immediately arise. What are we going to restore? Sometimes the bounds are obvious. Speaking for those who have worked around the Great Lakes, and in particular Green Bay, the ecosystem's bounds are not all that obvious. So what shall we restore? How shall we bound it? And to what do we restore it? Can an ecological base guide us in the restoration process? These are the basic questions.

The people of the Great Lakes have a common mandate. The binational Water Quality Agreement between the United States and Canada calls for the protection and restoration of the chemical, physical, and biological integrity of the Great Lakes ecosystems. The emphasis is placed on ecosystem integrity. We are now faced with trying to understand what integrity means—it means different things to different people.

This consideration brings us back to models when looking at science and its contribution to the restoration of ecosystems. Conceptual models may be no more than a picture, but they are based on some understanding and on certain assumptions. They may be deterministic models used for predictions. This raises the question: how good are our predictions? Or they may be empirical models or statistical models. We need and use a variety of models.

In guiding the restoration process, we require models that will help us understand what we need to restore and to what degree restoration is possible. We need to emphasize the ecosystem concept. New ideas and new models relating to ecosystem integrity are appearing and taking their place alongside accepted concepts and practices. They are holistic in nature. The following are three such models.

## Ecological Succession

A familiar conceptual model is that of ecological succession, developed independently in the early 1900s by Frederick Clements and Henry Cowles. This model deals with the temporal change in natural communities brought about by existing organisms, so called autogenic change. This involves changes in the environment, making it more suitable for another group of organisms, causing a type of progressive serial change. This change marches through time in a particular ecosystem, given an unchanging climate and a certain species pool, and ends in an equilibrium state. The ecosystem is self-organizing through the interaction of organisms (biological community). Certain structural and functional changes appear to be common to many forms of succession. For example, organic matter increases, standing crop biomass increases, diversity increases, food webs become more detritus based, and primary production is balanced by respiration. We view certain ecological characteristics or criteria associated with ecological succession as integrity indicators.

## Thermodynamic Framework

In another more recent model, James Kay from the University of Toronto suggests using a nonequilibrium thermodynamic framework to understand ecosystem integrity. He is referring to the first and second law of thermodynamics, that ecosystems develop along a thermodynamic branch. This concept has been presented in the *Journal of Environmental Management* and parallels successional theory.

The physical environment sets bounds for a developing biological community because the soil, geology, and climate differ in different geographic locations. These physical constraints cause organisms to develop along certain thermodynamic branches. One community replaces another by dissipating available energy. The model involves dissipative structures—organisms, including microorganisms. These organisms take advantage of available energy, solar or other sources. As time progresses, the community changes, with different organisms making more effective uses of energy until some optimum is attained.

Kay calls this an optimum operating point—the point where the forces that disturb the community are equal to the community's organizing forces. Some disturbance will always go on—including anthropogenic disturbance. A natural disturbance may shift the operating point back along the thermodynamic branch, in effect setting back succession. This results in a different assembly of organisms.

If the disturbance is relatively small, the system might progress back to the original operating point. However, if the disturbance is great, Kay suggests that the operating point jumps off onto another thermodynamic branch. The jump could be onto the same branch or onto a new twig. The disturbance, then, is of a magnitude or quality to restructure the community. Different organisms, taking advantage of subsidy energy coming into the community from direct sunlight or other sources, respond and restructure. Even if the community is different, it still may be recognizable on the same thermodynamic branch.

If our ecosystem were disturbed enough to jump off onto another thermodynamic branch, do we have the tools to get it back? If stress is being applied to the system and the stressor is removed, will the ecosystem go back by itself or must it be encouraged? And how can we do that? In other words, will the ecosystem's self-organizational qualities be sufficient to correct the pathology and restore the original optimum operating point?

## Hierarchy Theory

R.V. O'Neill, D.L. DeAngelis, and others give another view—a hierarchical concept of ecosystems. In ecological literature, hierarchy is usually identified with the concept of levels of organization. In a simple example (cell, organism, population, community ecosystem), each level is composed of the subsystem on the next lower level and is controlled in part by the level above it. This gives rise to the concept of emergent properties. Emergent ecosystem properties are the result of interactions and behaviors of various subunits and are not simply the sum of all parts. This concept is important because, to restore ecosystems, we must recognize and understand factors governing emergent ecosystem properties. Further, this model puts significance on rate functions—their importance and their different ecosystem levels. Ecosystems have two recognizable physical structures—vertical and horizontal. The horizontal structure can be different units of a landscape. For example, if we look at the landscape from the uplands to the lower lands, we see pieces of forests, individual wetlands, streams, or a receiving waterbody.

DeAngelis and O'Neill point to the importance of the connections between these segments, not only the activities within each unit. They use the term "holon" to define rate functions inside a unit, versus rate functions between units. They also maintain that the system's behavior and organization depends on the maintenance of differential rates within and between hierarchial units. Behavior of lower level holons are constrained by higher level. If constraints are removed, then process rates at lower levels begin to dominate the system. In this sense, system integrity is lost.

This model can describe elements in the Green Bay ecosystems. Beginning on the uplands in the drainage basin, hydraulic units become larger and larger as you progress downstream, finally ending up in Green Bay.

The bay enters into the Great Lakes—into Lake Michigan—and Lake Michigan is part of yet a larger ecosystem. One nested ecosystem goes into another. So where do we draw the bounds, and what have rate functions got to do with any of it?

## Self-Organizing Qualities of Ecosystems

These three concepts have at their base a fundamental premiss—the self-organizing qualities of an ecosystem. This relates to integrity. When an ecosystem loses its capacity for self-organization or its organizational structure, it has lost its integrity. When that happens, human benefits are lost as well. The science and art of ecosystem restoration is to restore the ecosystems' self-organizing properties.

That aquatic ecosystems manifest self-organizing characteristics is dramatically seen in the recovery of Spirit Lake after devastation from the eruption of Mount St. Helens Volcano in 1980. In 1991 Spirit Lake is again stable and life supporting, but the ecology is quite different from what it was before the eruption. It apparently developed along a new thermodynamic pathway.

The Green Bay ecosystem is a large ecosystem. Green Bay is 100 kilometers long and 37 kilometers wide, with 4,000 square kilometers of surface area. Within the bay's drainage basin are 41 different watersheds covering about 17,000 square kilometers. The ratio of land surface area to bay surface is over 4 to 1. When addressing the problems of the bay, the basic question is: what needs restoring?

## Analyzing the Problem

In southern Green Bay, total phosphorous (TP) is 190 micrograms per liter; chlorophyll *a* is 49.7 micrograms per liter; Secchi depth is .5; meter the mean depth is 2.9 meters (Table 1 and Fig. 1). Starting at the head of the bay in the south where the river flows in, and going north, values for TP and chlorophyll *a* decline. One of the Green Bay system's characteristics is a strong, abnormally steep nutrient gradient.

A thematic map taken from satellite images, produced by R. Lathrop and T. Lillesand at the University of Wisconsin–Madison, shows high total suspended solids (TSS) in the lower bay and improves as one proceeds north. The problem is not necessarily the whole bay, but rather at the head end of bay. At the top of the bay, the problem disappears. Even more dramatic is chlorophyll *a*. In certain spots, it measures 74.2 micrograms per litre. But its presence is patchy, not homogeneous.

**Table 1.—Trophic characteristics and food chain efficiencies (carbon transfer) of five regions of Green Bay (Figure 1). Efficiencies are calculated as ratios of production or yield for fish (FY), zooplankton (ZP) and phytoplankton (PP). TP = total phosphorous, CHLOR = chlorophyll *a*, Z = mean depth (from Sager and Richman, 1984).**

| | TP µg/l | CHLOR µg/l | Z | ZP/PP | FY/PP |
|---|---|---|---|---|---|
| 1 | 190 | 49.8 | 2.9 | 2.3% | 0.144% |
| 2 | 76 | 8.4 | 7.6 | 8.3 | 0.588 |
| 3 | 45.5 | 5.8 | 8.9 | 5.9 | 0.664 |
| 4 | 40 | 4.4 | 17.0 | 6.8 | 0.22 |
| 5 | 26.7 | 2.1 | 29.0 | 10.2 | 0.04 |

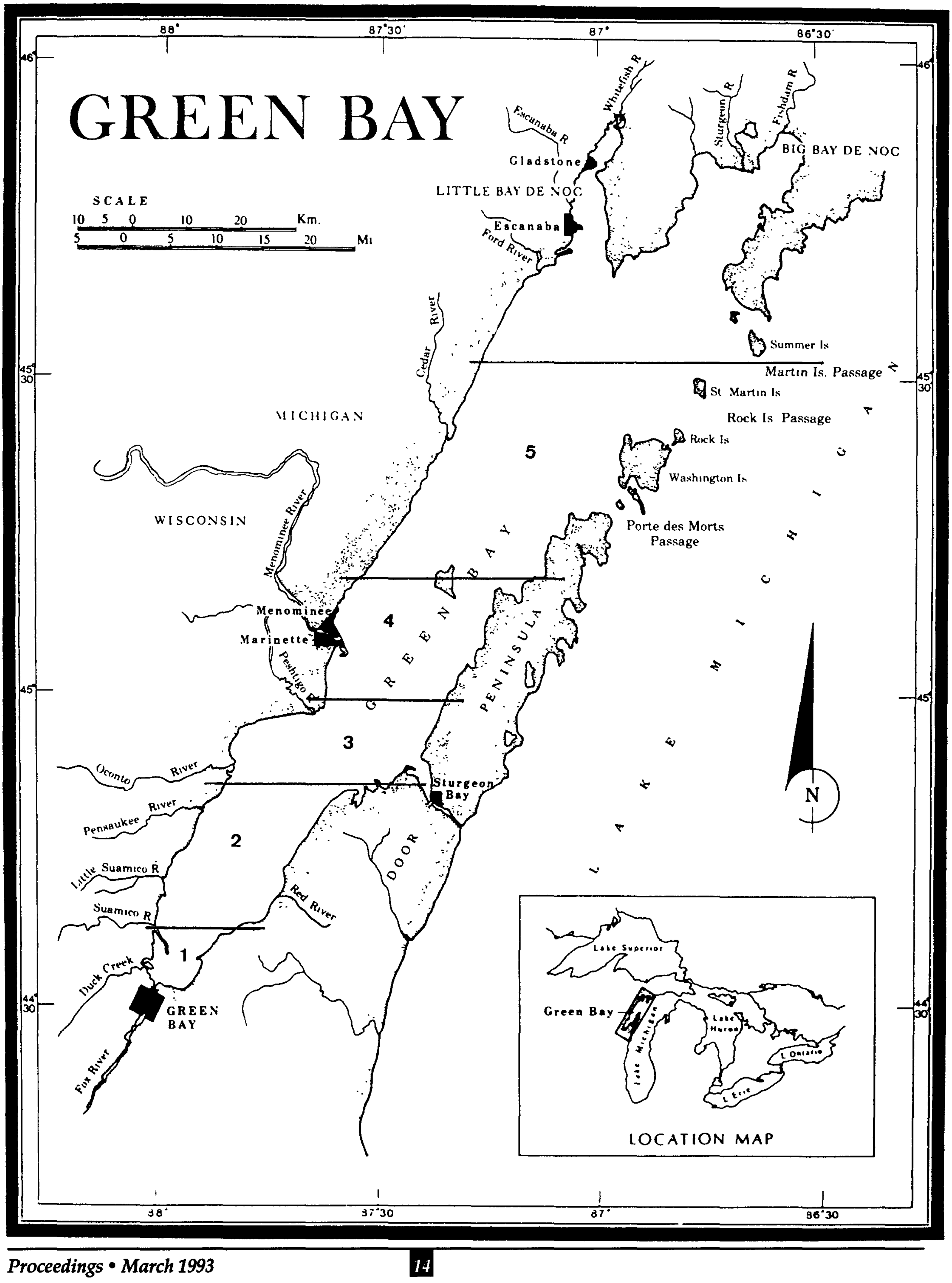
The relationship between phosphorous and algae is well documented. With too much available phosphorous and with over one million kilograms per year delivered by the Fox River, we can see some of the effects. In one of the few remaining coastal wetlands on the inner (lower) part of the bay, the seiche runs in and out like a tide on a fairly regular 10-hour interval. The turbid water, caused about equally by biotic and abiotic solids (algae and sediment) pushes into the marsh.

The effect of the turbidity is complex—simply put, it is shutting out the light. The effect on submerged aquatic vegetation is similar to that in the Chesapeake Bay and many other over-enriched estuaries—when the light is shut out, submerged aquatic vegetation can no longer grow. This changes the lower bay's whole structure with a major shift in the primary producers, particularly in the ratio of fixed carbon between the submerged aquatic plants and the algae.

The submerged aquatic plants are the habitat for other organisms— forage minnows, pan fish, basses, and northerns and where predator fish and perch spawn. Predator fish need this habitat. Without submerged vegetation in the marshes, the aquatic insects are reduced as well. The difference in the entire population is supported by good data.

Emerging insects are important to bird populations nesting in the marshes. Compared to marshes with low turbidity, the nesting bird

**Figure 1.—The bay of Green Bay, showing five regions, delineated by trophic characteristics.**



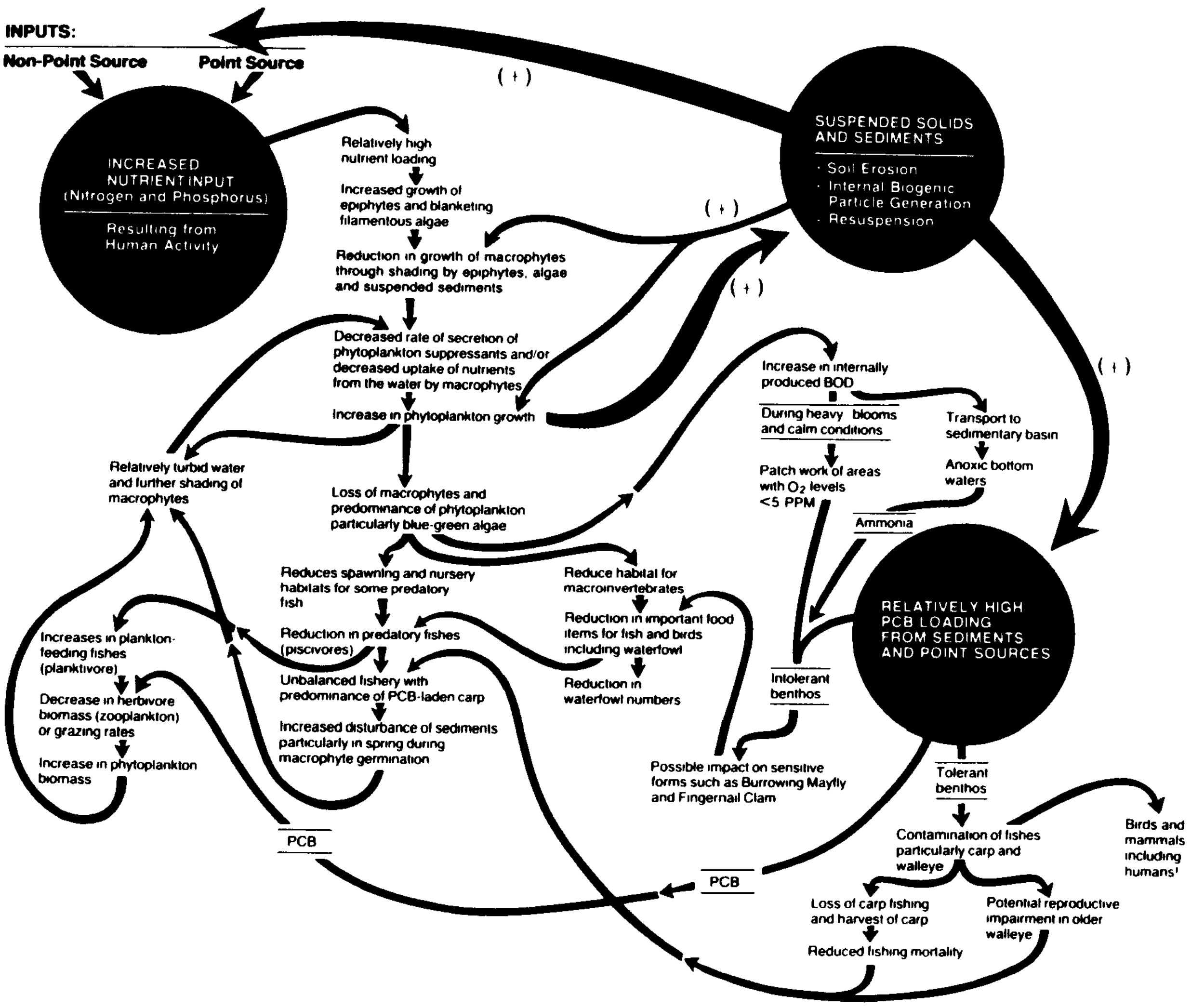
population in this marsh is about twice as high where submergent vegetation flourishes. While phosphorous and suspended solids are not the bay's only stressors, their effect appears to have shifted the ecosystem to a different thermodynamic branch.

## Ecosystem Interconnections

Everything appears connected to everything else (Fig. 2). Algae production and suspended solids affect available light. When submerged macrophytes die off, the energy flow shifts from littoral zone aquatic insects that live near shore to benthic forms that live in the pelagic system. Much of the algae dies off and sinks to the bottom. With the dominance of the planktivorous fish, zooplankton populations decline. The zooplankton community also shifts species composition, since many zooplankton can no longer take advantage of the phytoplankton, dominated by blue-green algae; blue-green algae are too large and unpalatable. Consequently, energy pathways are altered markedly.

An interesting study by Drs. Paul Sager and Sumner Richman looked at the different rates carbon is being used along Green Bay's trophic gradient. About 22 percent of the phytoplankton produced in the lower bay go through the zooplankton and then into other forms up the food chain. In the upper bay, 98 percent of the carbon produced goes through the pelagic food chain. Evidence reveals that the lower Green Bay's trophic structure has been altered, essentially following a new thermodynamic pathway. We see a change in the structure and we do not

**Figure 2.—Interconnections within the ecosystem affect all organisms and alter energy pathways.**

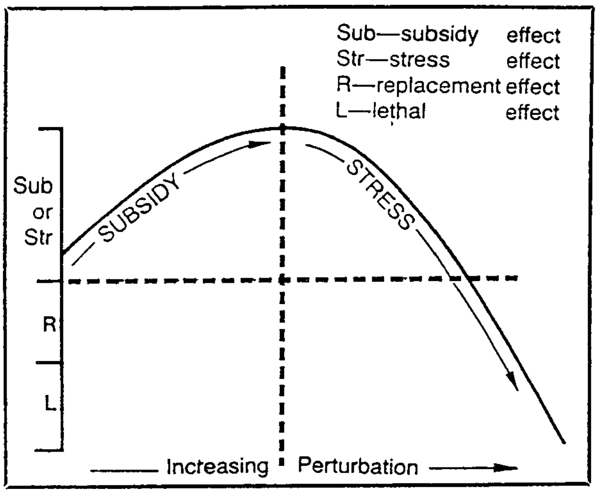


like it—we would rather have more piscivores than planktivores and more submergent plants on which ducks feed. We would rather have desirable benthos forms—fingernail clams and burrowing mayflies—that can no longer tolerate the oxygen depletion in the sediment because of too much decomposing algae. This situation ultimately connects to human activities on land as well as the integrity of the bay itself.

## Stress Ecology

Stress ecology endeavors to understand ecosystem changes brought about by natural or human causes. In Green Bay phosphorous and sediment loads act as stressors at the head of the estuary. In the midbay region, the stressors have been ameliorated by the system so that they no longer constitute a stress but rather appear to act as a subsidy (Fig. 3).

**Figure 3.—Hypothetical performance curve for a perturbed ecosystem subjected to two kinds of inputs (from Odum et al. 1979).**




While the impact of these stressors in southern Green Bay seems real enough, we cannot predict when the stressor becomes a subsidy or vice versa. Further, while we are confident that changes will occur if the phosphorous and sediments loads are reduced, we are not sure that the system will be restored to its condition before human-induced perturbations. Said another way, we are unable to predict the new optimum operating point. Nevertheless, we can develop models that specify tolerance limits of specific stressors on important Green Bay indicator species. Because the combined impact of phosphorous and suspended solids is on light attenuation and loss of submergent macrophytes, we need to know the minimum amount of light necessary to support desirable plants. From there we can prescribe the necessary reduction in phosphorous and suspended solids to attain the required water clarity. We need to set meaningful targets for restoration.

## A Model in Action

The most critical stressors on the Green Bay ecosystem have been identified as phosphorous, suspended solids, and PCB loading. By identifying these critical stressors necessary for rehabilitation and by knowing about the system's ecological structure and function, a set of ecosystem properties can be identified and used to guide restoration. For example, because submergent macrophytes are essential for restoring the bay's integrity, water clarity must allow light to be within tolerance limits for desirable submergent species. Likewise toxic substances (e.g., PCB) cannot be outside tolerance limits of keystone predators. The presence of desirable species, such as wild celery and Forster's terns, results as an emergent system property and can be taken as a measure of ecosystem integrity.

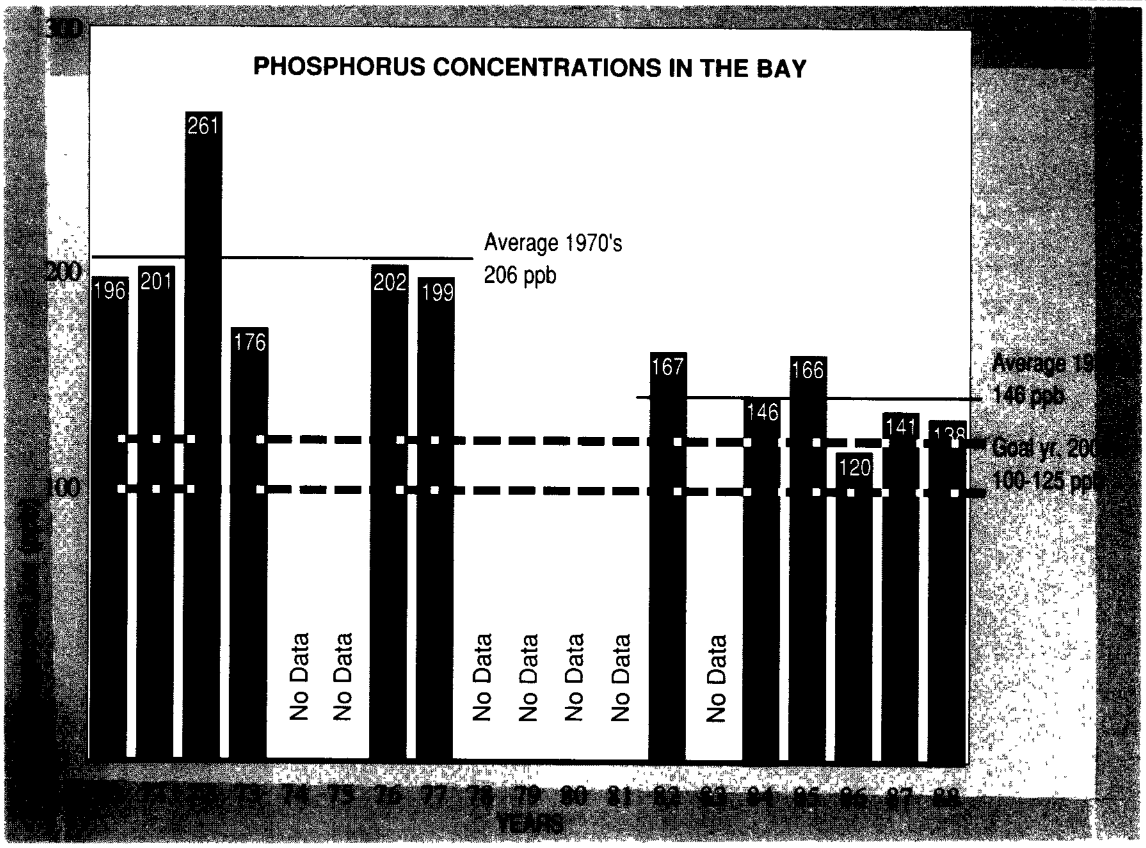
Consequently, we can focus our attention on developing models useful in defining the species limits. Such models have now been developed and management objectives formulated to meet these requirements.

## Looking at the Big Picture

In considering what to do about Green Bay's degraded condition, we cannot merely look at where the pathology has developed. To restore the bay, we must go beyond the bounds of the shoreline. The lower Fox River, which flows into Green Bay, is heavily industrialized and urbanized with many point sources. All of the point sources, particularly the municipalities, have phosphorous discharges. We must know how much is coming from the point sources and how much is coming from the nonpoint sources. Long-term monitoring helps us understand where ecosystems have been and where they are going.

In 1976, a one-milligram-per-litre phosphorous effluent restriction went into effect in the Great Lakes for communities with the equivalent of 10,000 population. Prior to that, phosphorous concentrations in lower Green Bay were 190 micrograms per litre (Fig. 4). In 1984, we began to see a change in average levels of phosphorous in effluents from municipalities. Phosphorous loading from municipalities was reduced 95 percent. As a result, we saw a 28-percent reduction in ambient bay concentrations—and it lagged.

**Figure 4.—The average concentration of all measurable forms of phosphorous, known as total phosphorous, collected from eight stations in the inner bay during spring and summer months. Data from P. Sager, UWGB and John Kennedy, Green Bay Metropolitan Sewerage District.**




This shows that the system is retaining and regenerating a certain amount of phosphorous. Phosphorous also is moving out because of the bay's short retention time—the residence time is less than 200 days.

## Mass Balance?

Studies by Dr. Val Klump from University of Wisconsin–Milwaukee suggest that only 25 percent of the phosphorous is being recycled. This kind of information also helps in setting limits. Various models indicate a need to reduce the phosphorous load by 50 percent. Empirical data shows that at least 50 percent of the phosphorous currently being loaded into Green Bay is coming from above Lake Winnebago. The watershed contains three main basins—the upper Wolf, lower Fox, and the upper Fox River—containing 41 watersheds. Empirical models help determine where the phosphorous originates.

## Why Use Models?

Models are tools, primarily used to define limits and improve our comprehension of natural systems. Conceptual models have limited utility to tell specifics about an ecosystem, like how much to reduce phosphorous loading to Green Bay or the best place to make reductions. But they are essential to help us change our notions on how the system works. For example, Kay's nonequilibrium thermodynamic framework (model) helps us understand the role of disturbance in ecosystem dynamics and, in fact, draws our attention to the system rather than the separate parts. Hierarchical theory (models) places emphasis on nested functional units and ascribes a system's integrity to the modifying influence of "higher" units on lower ones. As we have altered larger landscape units in watersheds (e.g., removal of wetlands, changes of stream courses and drainage patterns, and land cover), rate functions such as soil and nutrient loss have speeded up at the field level. These "run away" rates dominate the processes in the whole drainage basin and end up as a major stressor on the receiving body of water—Green Bay. Green Bay has responded to these stressors by reorganizing along a different thermodynamic branch.

While conceptual models can change our perspective, they are not particularly useful in defining ecosystem recovery limits or deciding on the most effective means of rehabilitating ecosystems and restoring human beneficial uses. Consequently, we find ourselves involved with an array of stochastic models based on deterministic assumptions and empirical evidence.

In Green Bay we have used empirical models to set limits on ecosystem stressors, such as phosphorous, suspended solids, and PCBs. They tell us in useful terms the amount of remediation needed to initiate ecosystem recovery. Yet these models do not tell us what is possible in reaching goals of system recovery and restoration of beneficial uses. To this end, we turn to watershed models for a more holistic picture.

Watershed models allow us different perspectives with different resolutions. For example, a model called EPIC provides edge-of-field analysis. The EPIC model is a process model, operating on a daily time-step basis, composed of physical, biological, and economic components. This model is data intensive and tracks crop growth under different management practices. Other models are useful at the edge of watershed scale (AGNPS) and at the basin delivery scale (SWRRB) when attempting to simulate changes of agricultural practices and the resultant phosphorous and sediment reduction to down-stream receiving waters.

While problems exist in coupling these models and ascribing levels of confidence in the resultant outputs, they do give us insights about the cumulative impacts of individual actions on receiving waters. They give us the ability to simulate land use changes and first-order-of-magnitude estimates about our future direction, depending on whether or not we make changes in land use practices.

Human interaction with the environment is usually at the farm/field or developer/lot scale. These models at least allow us to see our capabilities, given the present economic conditions and the projected economic future. Herein lies the crux of our ability to restore ecosystems—we need to interface ecology and economics. This is the challenge. We are dealing with more than the cost effectiveness of reducing a unit of pollution—we are trying to understand at what level we can produce commodities and still have important elements of integrity restored to the land. The stress is on the land; we see the manifestations of that stress in Green Bay.

## Economic Rationality

While ecosystem science is imperfect, it is based on ecological principles and rationality. Ecological models admittedly lack precise predictive capacity. But then, what can we say about our economic models? A number of modern writers (Caldwell, Dryzek, Bartlett) point out that we could have more than one form of rationality in our western society; that is economic rationality. These authors, along with others in the past (George Catlin, George Perkins Marsh, Aldo Leopold), call for an ecological rationality on par with economic rationality in our present decisionmaking system. I agree. The science of restoration ecology is good enough to make decisions now about the present and the future. To delay for "better science" is not ecologically or economically rational, nor is it in our own best interest to continue making decisions primarily on the basis of economic, legal, and political rationality. The science of ecology is mature enough to support the accepted use of ecological rationality.

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## The Status of Restoration Science

# Wetlands Ecosystems

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In describing the status of wetlands creation and restoration science, one question stands out—can we restore the functions of existing wetlands? Over the past five years as part of its Wetlands Research Program, EPA has been evaluating not only restoration, but also creating and enhancing wetlands. These approaches fit together in considering the ability to replace the functions of wetlands.

A few years ago, the EPA commissioned Jon Kusler and me to develop a status report on the science of wetlands restoration and creation. We enlisted some 30 scientists and experts from across the United States to prepare this document. At that time, interest in creating and restoring wetlands was just starting to blossom. Since then, a lot has happened and much information has been published. However, the document's overall conclusions still hold true.

Functional replacement has not been demonstrated for two primary reasons. Until recently, project monitoring has been extremely rare, producing little quantitative information. More importantly, the vast majority of projects are ecologically young. An age frequency distribution curve results in almost all projects grouping at the scale's lower end, between one and 10 years of age. When evaluating only young systems, we cannot say unequivocally that we can get what we wanted when we started out. However, our growing experience and best professional judgment indicates which situations might work.

## Functional Replacement

Functional replacement varies depending on the wetlands type, the function needing replacement, and geographic region of interest. Considering the ability to replace wetlands, we have the most information about tidal wetlands and the least about inland wetlands. In general, as the hydrological complexity of the system increases, our knowledge decreases as does the probability of getting a desired result. Tidal systems are among the more hydraulically simple systems—at the right elevation, the tides take care of the hydrology. For the water quality function, we know the most about the ability to remove nutrients. We know much less about heavy metals and least about the processing of anthropomorphic substances, complex human-produced compounds. As to the habitat function relating to wetlands, we know the most about commercially or recreationally important species such as waterfowl, fish, and timber. We know much less about the species at the lower end of phylogenetic tree—mosses, algae, microbes, invertebrates and lower vertebrates like amphibians and reptiles.

Concerning geographic regions, we know most about wetlands of the Atlantic Coast. Our knowledge decreases as we go from the Atlantic Coast to the Gulf and the Pacific, and drops off again as we move inland. We have the most information and can write the most scholarly reports on the status of the science of wetland creation and restoration of the *Spartina alternaflora* (cordgrass) marshes of the lower intertidal region of the Atlantic Coast.

## Selecting Success Criteria

Preparing the status report required synthesizing many diverse points of views to reach general conclusions and consensus. One difficulty in reaching consensus was selecting success criteria. Existing information is general and not easily quantified. Goals for projects are seldom stated. Another difficulty is limited information on wetlands. Traditionally, wetlands have not attracted researchers. That wetlands have not been of interest is illustrated by the lack of wetlands species in a typical university herbarium. While many want to collect plants in the prairies and forests, few are willing to brave the muck and bugs to collect wetland plants. Only the past 25 years has seen some continuing interest in creating a body of science about the general ecology of wetlands. Therefore, setting goals for restoration is difficult without understanding the system being restored.

We have been shortsighted in requirements for restoration monitoring. It is fortunate to secure five years of monitoring information, which is an insignificant period on an ecological time scale. Data from our research at EPA shows that wetlands projects—particularly those dominated by herbaceous vegetation and one-to-five years old—were an age class. We need a longer perspective in looking at these systems, their changes over time, and information to indicate what is possible and how it relates to what exists in natural wetlands.

The following examples come primarily from studies of the EPA's Wetlands Research Program that evaluated wetlands mitigation projects nationally. We looked at the most common freshwater mitigation project nationally—a pond with a fringing freshwater marsh. Similar studies were conducted in three different parts of the country. Dr. William Niering led the Connecticut research, Dr. Mark Brown of the University Florida's Center for Wetlands led research there, and I led research in Oregon.

## Study Findings

Typically, the literature contains status reports that are the result of case studies. The program designed for EPA differs in its emphasis on what is going on in general—not on a "pet" project—by sampling populations. This approach provides information on the realm of possibilities regarding the status of natural wetlands and wetland projects. The results of the three studies can be grouped into three categories.

First, some of the differences between the natural wetlands and the projects are related to age, since projects are ecologically younger than existing wetlands. Over time, these characteristics will likely become more like those of existing wetlands.

The remaining categories are disturbing because they relate to human decisions and actions. Studies show fundamental differences in the way these wetland projects compare with wetlands typical of the region. In all three studies, finding natural analogues to the projects was difficult. Despite attempts to choose an appropriate population of natural wetlands, in all cases—in Connecticut, Florida, and Oregon—fundamental differences existed between the natural wetlands and the projects. The most obvious example of these fundamental differences between projects and natural wetlands is that we are designing our projects to be systems dominated by open water.

Finally, a number of differences were related to poor design and implementation.

## Result Examples

In the Oregon study, an average 90 percent of the site was open water. In the natural wetlands, some 78 to 80 percent of the sites were vegetated. Therefore, the proportion of the sites with open water as compared to vegetated is reversed.

In examining water level data from the Connecticut project, the pattern of the wetlands project differs from that of the natural wetlands. During much of the year, the natural wetlands had saturated soils, while the project had water standing deep on the surface. Also, the natural wetland had a greater degree of variability with fluctuation of water depths throughout the year than in the projects. We do not know the ecological effects of these fundamental differences; we just know they exist.

In mitigation, the most recent status report on wetland acreage by the National Wetland Inventory finds a trend in freshwater wetlands away from the marshes and forested wetlands to open water. Regional shifts relating to permitting and national shifts relating to human changes on the land result in changes from the original type of wetland in a region to a different type. We do not know the ecological effects of these changes, but through our manipulations we are creating something that is different than what existed before.

Another example of poor design from the Oregon project has been seen in other parts of the nation—areas of projects typically are smaller than what was permitted or designed. In Oregon, none of the projects were constructed as either permitted or designed. Some of the changes were positive—if the planned slopes had been accomplished, the sites would have been dangerous. In fact, some are. The difficulty is that an acre of ground does not produce and acre of wetland. No substance other than a concrete wall would allow digging straight down to the water level to create an acre of wetland out of an acre of land. Steep-sided ponds occur from trying to maximize wetland size on a small plot of land.

Despite the fundamental changes in structure and potential function, there is some good news. While we do create features different from those in natural wetlands, some age-related factors indicate that restoration, creation, and enhancement are tools we must learn to use better. In data from Oregon, also reflected in data from

Connecticut and Florida, the natural wetlands have higher soil organic matter and a higher degree of plant cover than the projects. However, the new sites have a greater plant diversity. Over time as the plant cover increases and competition for resources rises, diversity will likely decrease and become similar to the natural wetlands. As those plants contribute organic matter to the soil, organic matter will increase.

## Fundamental Questions

In looking at projects, the reason they were established in a particular location is not generally obvious. Siting of projects is an emerging issue and one of the major themes of the Wetlands Research Program for the next five years. Often activities surrounding a wetland can disrupt the functions that cause the wetland to exist. This presents a fundamental question that affects the extent restoration is possible on a site. What will the site be like in 20 years? How do you guide the land use in vicinity of the wetland or establish buffers to protect it from the surrounding influences? How do these activities—particularly urbanization and agriculture—affect our natural systems, and how can we better site restoration projects to improve the functioning of the landscape?

## Conclusion

Information on wetland creation and restoration is increasing. More and more publications are reflecting this. In fact, last fall the U. S. National Oceanic and Atmospheric Administration published the next version of the status report on creation and restoration. This collection of papers, edited by Dr. Gordon Thayer, reports on the restoration and creation of tidal wetlands.

As we learn more, the scientific questions are becoming more complex. When work began on the status report, if a site was "green" with approximately 80 percent cover within two years, it was considered successful. Today, we find that "green" does not automatically mean success. Plants growing on a wet site do not necessarily indicate a fully functioning system.

Work with tidal systems is suggesting that once hydrology and plants are established, the next critical factor is soil processes. Some evidence suggests that without happy soil microbes, there are ramifications throughout the food chain. This topic will receive much attention in the coming years.

Once the hydrology is right and the plants are established, what else makes a healthy ecosystem? The jury is still out. Information is coming out of work in progress. The major problem is that these systems are ecologically young. We do not know yet if something restored will be persistent in the landscape or what kind of efforts are necessary to maintain them.

The status report overwhelmingly maintained that a system dependent on significant input from man is likely to fail. So we must design wetland projects to exist in the landscape the way natural systems do and be part of an existing management program. To better understand how to do this, we need to look at these systems over a longer time.

Finally, the biggest barrier to potentially using the tool of restoration as part of resource management is the history of poor implementation and design. Experts in the regulatory arena, including the new EPA Administrator Carol Browner, favor restoration over creation of wetlands. In some cases, however, creation may be the management tool of choice. But unfortunately, past performance shows that promises have been broken; and the disasters left behind have erected a barrier to the use of wetland creation.

An author of the status report, Mark Fonseca of the National Marine Fisheries Service and an expert in seagrass restoration, suggested a question to ask when making a decision about a project. Can you afford to lose this system?. This holds true whether in a regulatory situation looking at a section 404 decision where the site in question is to be destroyed or in restoring a degrading system. Even a degraded system is, by definition, performing some functions. For example, southern California has highly degraded systems, but those systems are an important habitat for endangered species. In restoring them, you take the chance of doing something harmful, i.e., losing the habitat.

This question must be addressed up front before proceeding with the restoration, the creation, or the enhancement—and learn by doing. Current projects reflect limited attempts to learn from past mistakes. We must make an effort to see what is happening and document what was done.

A big difficulty we had in our evaluation studies was determining what had been done on projects. We were forced to generate our own site plans because we could not identify what was done by talking to the people involved and by examining the records. We must know what was done and follow up on that effort to learn from it. And as Theodore Roethke said, "Learn by going where we need to go." ❑

# The Status of Restoration Science
# Terrestrial Ecosystems

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Before beginning restoration, one must first ask: In what way is the ecosystem degraded? Any restoration process should start with an assessment. The assessment should be based on several questions: What are the processes or functions that are not working properly? What is missing from the system? What are the forces or impacts that are affecting the system?

Second, one must determine how to restore the system. Again, questions follow: How do we put it back the way we want it, and how do we want it? What is the end result to be? How do we achieve it? Unless we know the problem, we cannot begin to fix it.

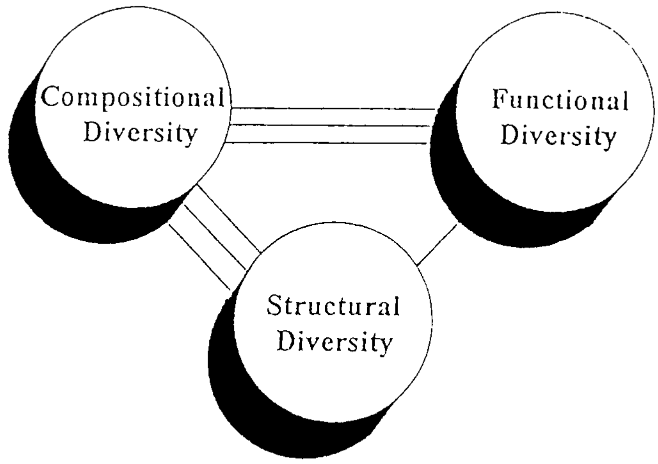
Finally, we must establish criteria for determining when we have arrived? How do we know when the situation is fixed? What are the benchmarks or goals and what is our specific aim in setting up the restoration strategies?

## Interrelated Components of Ecosystems

A model helpful in understanding restoration comes from recent work in landscape ecology and biodiversity mitigation (Fig. 1). An ecosystem contains three fundamental components so completely interrelated that they cannot be separated.

Ecosystems have a compositional diversity made up of many parts. Genetic entities from ecotypes to individual species, are the best-known component but are associated in many ways. The associations, from micropopulations to communities distributed across the landscapes, are important to diversity. These are often called structural diversity. A second diversity component is functional diversity. Nutrient cycling, energy conversions, organic accumulation, and soil maintenance are all part of those functional components necessary for the system to operate.

**Figure 1.—Ecological diversity.**




The third component is structural diversity, particularly important in a terrestrial ecosystem. Structure is largely provided by the species and the way they are assembled. In old growth, for example, structural diversity has received much attention. This includes big trees and dead trees, woody debris, and organic debris of various forms across and within the soil in various combinations. Structural diversity, largely related to vegetation, provides niches for other species including other plants.

## Dysfunctional Ecosystems

If any part of these components is missing, then the ecosystem is degraded. It will not function as well, nor be as tight or as able to carry out ecological processes efficiently or completely. In theory, if any species or single piece of structural complexity is absent, the ecosystem will not be fully functional. That raises the question yet to be answered—is it sustainable? We simply do not yet know. A severely degraded system is clearly not sustainable; some partially degraded systems are probably sustainable.

What is a dysfunctional ecosystem? One of the best indicators of a dysfunctional ecosystem is water quality. As a terrestrial ecosystem becomes dysfunctional, for example, soil integrity is reduced. The soil maintenance process is elaborate, requiring the interaction of many organisms and energy. Soil integrity relates to nutrient cycling, among other processes. As soil becomes degraded and the soil system maintenance begins to fail, soil erosion is an inevitable consequence. While a system may not have particulate erosion—that is, suspended solids or bed load leaving the system—it certainly will have dissolved materials leaking from the system in a different way than if the system were completely intact. A change in nutrient cycling results in nutrient leakage. This has been well illustrated in the work of Borman and Likens at Hubbard Brook.

Second, a dysfunctional system will have changes in its productivity. While difficult to measure, productivity can be examined in several ways. For example, chlorophyll a reflects primary production. Primary production is the fixing of energy by green plants—the photosynthetic process. A dysfunctional system will be different. The dysfunction may result in enhanced primary production, for example, from more phosphorous in an aquatic system. In an extreme case, primary production is degraded. In either case, the change in the amount of energy entering the ecosystem will create a perturbation.

The question is whether or not the system can adjust. If the system is degraded—if species are missing or functions are not working—then the system is less able to adapt to the changed primary production. This leads to the overworked analogy of the spider web—as we lose more and more parts, the system becomes more unstable or less capable of adjusting to perturbation, such as the change in primary production.

## Primary Production

Primary production is obviously related to bioaccumulation. In a terrestrial system, it contains two important parts—soil maintenance and standing crop biomass.

The need for soil maintenance is related to bioaccumulation, with organic matter being constantly replenished in the soil. Organic matter's half life as it enters the soil system varies according to climate, location, typography, and other factors. But organic matter is constantly being oxidized and lost to soil organisms. When lost, it must be restored, because the organic matter is an important part of the terrestrial system.

This is also true for the standing crop biomass. How much living energy do we have in the system? How is it distributed from the roots up through the plant community to the top of the canopy? Standing crop biomass is important not just to plants, but also to the animals that are utilizing those plants, and animals that live on those animals. As plants die, primary production is necessary to replace their structures.

## Ecosystem Diversity

We have recently heard much about diversity, a critical part of the system. A dysfunctional system will have different diversities; and almost inevitably—there are exceptions—diversity is reduced. Dysfunctions usually occur if the system is disturbed by some force—to which species and associations have not adapted through evolution. Typically something is lost and diversity declines—sometimes dramatically.

Diversity can decline even with an increase in primary production. This is frequently true, for example, with exotic species, particularly in forestry and agriculture, used to increase overall primary production. Monocultures may have high primary production with extremely low diversity.

Experts do not have hard answers on the question of stability. Basic biology and ecology texts for many years have suggested, without proof, a direct relationship between diversity and stability—when diversity goes up, stability goes up, and visa versa. We could conclude that when diversity goes down, ecosystem stability goes down. The relationship between diversity and stability is indirect. The relationship is linked—one being functional, the other being compositional.

Proving cause and effect in dealing with such complex relationships is difficult. Intuitively, most ecologists accept that if diversity decreases substantially, the system overall will lose some stability, but in a nonlinear relationship.

## Risk Assessment's Role

Risk assessment, now being applied to analyzing dysfunctional ecosystems, plays a role in restoration. Risk assessment involves three steps. One must analyze the impact's severity. This goes beyond the basic question of how the system is degraded to determining how severe it has degraded. Usually degradation has more than one aspect or cause. Each must be assessed.

Second, one should determine the degree of scientific confidence in the analysis. This requires more work. This is important, because unless we have reasonable confidence that the problem is correctly analyzed and properly assessed, we might be taking unnecessary steps and causing more damage than good.

Finally, how amenable is the problem or problems to management? Can anything be reasonably done? Do we have the will to act? Are we willing to pay the cost and put in the effort to do what must be done to restore the ecosystem?

Once this assessment process is complete, we can take several restoration approaches. We have analyzed the system and decided that it is dysfunctional. We have a reasonable idea of the problem and a reasonable strategy or goals to accomplish restoration. If we believe that it is worth the effort, we proceed.

## How Do We Proceed?

First, recognizing the dysfunctional ecological processes that are not working is absolutely essential. In most cases, nature is remarkably resilient. We should never underestimate the restorative powers within the natural system. The same concept applies to medicine—the ability of the body to heal itself is phenomenal. Just as the body must have a fighting chance to restore itself, the same is true of ecosystems. We must restore, or at least assist the system to restore, the ecological processes.

Several ecological processes are often overlooked; these are mostly the result of human intervention—sometimes purposeful and sometimes accidental or indirect. The perturbation regime is often not understood, particularly by those who are not ecologists. Nature is a dynamic system. The world is always changing—from day to night, through the seasons, and through climatic fluctuations, such as glacial periods. Other landscape conditions are also discontinuous—lightening, fire, wind, insect epidemics, among other phenomenon. Natural ecosystems have adapted to natural disturbances through the evolutionary development of species and associations.

Often, the problem is as easy as recognizing that humans have disrupted one of those natural perturbation regimes and restoring it. Sometimes that is all it takes. Later I provide examples of systems restoring themselves in a matter of a year or two following restoration of disturbance regimes. Obviously, such systems were not horribly degraded. In addition to a missing or upset perturbation regime, the frequency and intensity of the regime, the pattern, seasonality and size of the disturbance regime, and the type of the missing perturbation regime are also important.

## Altered Hydrology

Another ecological process often disrupted or altered is hydrology. While we immediately associate this with wetlands, we often overlook it within the terrestrial landscape. Other than fire suppression, we probably have altered hydrology more than any other natural process on the landscape. In riparian communities, for example, species and associations have evolved to deal with periodic floods—not only frequency, but also duration, time of the year, and length of time the landscape is flooded. These factors are related to primary production, nutrient cycling, and the other functions and processes discussed earlier.

In many terrestrial systems, we have lowered the water table through draining. Landscape flood patterns have been altered as streams were channeled, dammed, and otherwise changed to alter the normal water flow across the landscape. Even highways disrupt natural channels with culverts that in no way duplicate the natural flow of water and can cause serious disruptions of the hydrology. Hydrology is very complex, costly to restore, and may have serious economic conflicts.

## Bioaccumulation Processes

Bioaccumulation processes are much more difficult to work with, but some things can be done. Community structure is bioaccumulation of sorts. In the previous paper, we see how the standing crop biomass in terrestrial or aquatic communities is related to development through successional processes. Humans can do some things with community structure, but nature does this best. Nature only needs a chance to put the community structure back together.

We can do many things to help encourage species to come back, even though part of the structure is missing. Lacking snags, we can use nesting boxes for birds, for example. Mulching can replace much of the organic accumulation missing in a degraded system and begin soil recovery, nutrient cycling, protection against erosion, and assist in other ways. We often must restore organic matter to the soil in a severely degraded system such as abandoned mine spoil. We must address the total ecological system because the pieces are linked together—the pieces are part of a bigger whole. Green Bay is an excellent example of these linkages. Processes and structural problems within one ecosystem are linked to other ecosystems, such as through water pollution as a result of leakages in the terrestrial systems in the watershed. We need to make sure linkages are positive.

For example, dealing with organic matter restoration would be easier if we couple the solution to the organic waste problem in our cities. On the other hand, we can do little about nutrient cycling and retention; we can restore the species and some of the processes and let nature do the rest.

With diversity, several things should attract our attention. First, we must be keenly aware of dominant species. What is missing? What should be there? The dominant species provide structure and process for other species, but they cannot do it all.

Second, keystone species—whose presence or absence have a particularly important impact on many other species—occur even among the less dominant species. On the natural landscape, for example, a beaver is a keystone species. Its presence creates structure and opportunities for many other species that could not exist without the beaver, or at least without some kind of artificial restoration of the processes and structure that the beaver represents.

## Sensitivity to Rare and Exotic Species

We probably are overly sensitive to rare species. While rare species should be a concern, it should not dominate our restoration efforts. If we restore the entire system, rare species may or may not respond. Some are extinct. We should not waste our energy trying to restore rare species to a dysfunctional system, because they probably will not be successful in a dysfunctional system.

We have much to learn about minimal viable populations. Degraded systems and populations can be reduced to a point where they can no longer maintain themselves. This can result from broken linkages between communities and associations of ecosystems interfering with genetic exchanges that are essential to maintain species. Recognizing the critical level of populations, particularly of the keystone and dominant species, is an important part of restoring an ecosystem.

Exotic species increasingly are a problem. Some have the potential to totally disrupt the ecosystem. The best protection against invasion of exotics is to restore the natural ecosystem to health. Although a natural ecosystem is remarkably resistant against invasion, exotics can still get in. The healthier the system, the less likely this will happen or create serious consequences. Once exotics are well established and the system is degraded, extraordinary measures often must be taken to remove species such as buckthorn, zebra muscles, or purple loosestrife.

Communities are important to protection of diversity. Some species require certain kinds of associations and communities for one phase of their lives, and then spend another part of their lives elsewhere. Recognizing the linkages between these systems is important. We might do a perfect job of restoring a system but fail if we ignore the linkages. A system will slowly degrade if we have not restored the linkages necessary to allow organisms to move from one system to another.

## Consider the Landscape

Landscape features are also important. We should not become so preoccupied with restoring a single entity to the landscape that we overlook essential components of the bigger system. The entity—whether a wetland, a terrestrial community, or a species—will function and survive only because the entire health of the landscape has been restored. Nothing can survive in isolation. Ultimately, this affects the entire globe. While beginning with a local problem, we should not overlook those processes and linkages necessary to restore the entire system to health, sufficient to be self-sustaining.

In reality, old growth may not be too important. In an area where certain species survived and others could not, old growth becomes part of the whole. But we cannot restore every terrestrial and aquatic community to a totally natural old growth system. Core areas and critical habitats, important primarily to protect certain species, are part of a bigger picture. Using gap analyses and other studies, certain types or associations which are missing can be identified to keep other pieces healthy and allow components to interact in a natural way. Succession will always occur and is best seen as a process of ecosystem development. Whether we reach the end point of succession or not is less important than allowing the process to occur.

## Need to Monitor and Assess

Whatever we do, we must monitor changes. In the case of processes that will take generations to repair, others who follow will not know how to pick up where we left off unless we keep good records. Monitoring allows us to know that we are moving in the right direction.

Populations or indicator populations—associations of populations of many organisms—are a starting point. What occurred before settlement is a common reference point. Water quality and nutrient fluxes are always good indicators of the system's health.

Some natural processes are far more significant than we ever will be. Nature has evolved to deal with phenomenal disturbances, catastrophic in local areas and important even on a global scale. Through succession, nature can take the most extravagant event and reduce it to something remarkably benign. The process of restoration must work with, not against, nature. Humans have been responsible for the loss of many irreplaceable species—our ecosystems will never become fully functional again, so the repair processes will forever remain partially impaired.

## The Successional Process

In starting with the agriculture process—all too familiar here in the Midwest—diversity primarily consists of a single species with a few associated microorganisms and a few insects, which we do our best to eliminate. Large quantities of fertilizers cause large amounts of erosion and nutrient enrichment of our streams, groundwater, and wetlands. Successional processes will put the pieces back together, but slowly. Restoration of fallowed agricultural land might take several hundred years.

Over time species, if they still exist, will eventually find their way back. If humans allow succession to go far enough, the ecosystem will eventually reach the point where it will continue to perpetuate itself.

A good measure of the process is water quality. In a pristine natural system, the quality of water that drains from the system—lacking some natural disturbance—is remarkably clear; we would not hesitate to drink it. This water will have remarkably few nutrients and very little suspended solids.

Natural processes sometimes involve disturbances that return the system to its previous condition. For example, the beaver in a stream might create a wetland, causing a severe disturbance to the surrounding terrestrial community. This might also open opportunities for species, such as ducks, that otherwise would not exist. The beaver move on once the food supply has diminished, and nature again restores that area to a wetland meadow and, eventually, to a natural forest.

This is a totally natural process. The landscape itself is a mosaic of different community types and associations, successional series, and topography. Humans disrupt the landscape and ecology, such as clearing the natural communities and tilling the soil. In an attempt to recreate the forest, we can make terrible errors. For example, three attempts to reestablish a forest after a clear-cut in Superior National Forest were unsuccessful. The approach was to shear any remaining woody vegetation and shrubbery, apply herbicides to remove competing woody vegetation, and plant red pine. Left alone, in 200 or 300 years nature will restore the forest very much like its original condition.

How can an old agricultural field, with persistent exotic species like quack grass, revert to a natural forest? We can plant it to a forest, but it will still take 200 or more years to acquire the natural associations it once supported. After fire, a natural forest can return in about 50 to 60 years, as opposed to the several hundred years needed for reforestation from agricultural.

Process and diversity have an interesting connection. In a natural forest that burned 75 year ago, for example, a goshawk built a nest in an aspen tree. Goshawks are uncommon and in some areas are becoming a threatened species. However, the fire created a community on which the goshawk depends. So what is the connection between the goshawk and fire?

In addition to the mix of aspen and conifers in which goshawks nest, food is also a limiting factor. Underneath the goshawk nest is the remains of its food. In a nearby area, a widespread wild fire raged over 10,000 acres. This area of northern Minnesota is very well adapted to dealing with catastrophic wild fires. A year later, the successional processes result in a terrific flush of growth in the herbaceous layer because of released nutrients that otherwise were tied up in a relatively nutrient deficient environment. This, among other things, means a rapid growth of fringed binweed, an annual plant related to rhubarb, growing luxuriantly. In examining the remains of the ruffed grouse that the goshawk brought back to its nest, we find its crops filled almost exclusively with fringed binweed seeds.

The goshawk spends most of its time foraging on the recent burn and nests in a community that was restored by succession 75 years after a fire. We must not undervalue these linkages from one association to the other across the landscape; they must be put back together. The community has structure; each species, the entire association, and the ecosystem depend on linkages with other systems.

Northern Wisconsin has vast areas where fire, which typically occurred every one to 20 years, has been taken out of the landscape. When we take that process away, diversity falls off rather dramatically. We can put fire back into the system with prescribed or wild fires. Foresters look at the results and are aghast that all the timber has burned. The diversity, however, will be three-fold greater in this fire-dependent system than in a forest without fire.

Fire or other natural disturbance can help rare species exist in the system. An open wetland in an oak woodland in the upper peninsula of Michigan contains an aster that grows primarily along the shores of Hudson Bay and a rush that occurs primarily in the east St. Louis area in central Illinois. They occur together in a very remarkable association in a fire maintained savanna. Take the fire away and those species would be extinct in Michigan.

A species grape fern once had only two known locations in Wisconsin. Ecologists recommended that the areas where it grew be burned because they were historically burned. Rare plant botanists worried that this would eliminate the ferns. Fire was restored to the system and now thousands of this species of grape fern are on the landscape.

The timber wolf can only be restored to the landscape through the broad associations of many related ecosystems. All must be reasonably healthy and allow the wolf to move between them. We may not be able to achieve this level of regional restoration, but if we do not try, we will never get there.

## Conclusion

Restoration should follow logical steps. First, assessment. What is the condition of the ecosystem that we are interested in restoring? Once we know the condition and determine that, in fact, we want to restore it and know what the problems are, then we can put the processes and the system back where we want it. Assessment—analyzing the problem and deciding what steps to take—is the first procedure for all restoration and monitoring. Second, monitoring will allow us to evaluate our progress. This becomes the measure of our success.

Unless we address restoration at the landscape level, we can still fail in spite of site successes. In one example, a well-maintained oak savanna in the Midwest has over 300 vascular species in 7 acres. It is maintained by fire and contains remarkable diversity. All the processes are there. But it will not be able to exist indefinitely unless we restore the surrounding areas upon which it will ultimately depend for genetic exchange.

We must give nature a chance to work. Ultimately, we must recognize that the global ecosystem is the system we must restore. ❑

# *PANEL: Decisionmaking and Priority Setting*

PANEL: Decisionmaking and Priority Setting

# Goal Setting and Targeting in the Landscape

William (Bill) Jordan
*Society for Ecological Restoration*
*Madison, Wisconsin*

The conference organizers have given us a chance to pull together some wisdom from the restoration and conservation community about making decisions and setting priorities in the restoration business. We will concentrate on a few areas: what different methods and approaches exist for setting goals and targeting actions, and what is the appropriate scale for restoration projects.

One important question is this: how do we involve stakeholders and educate the public? Also, how do we make decisions and establish priorities in doing restoration work? In conservation circles when we talk about decisionmaking and priority setting, we are talking about the landscape. Nature is separate from people; the conversation tends to be essentially technical and scientific.

## The Dominant Species

The top priority, however, is to recognize that our species is now the dominant species in any landscape, here in the Midwest anyway. And arguably, we are a dominant species on the planet. We must understand that we are shaping these ecosystems, and that we will shape them whether we do so deliberately or not. Basically, the plans we come up with and the priority decisions we make will be projected on the landscape. They are a kind of analogue of the Australian aborigines' song, by which they believed themselves to be singing the world into existence.

The plans we make, the decisions we make, the way we decide to define the ecosystems that we undertake to restore and manage will, over time, become the landscape. It is up to us. For that reason, it is very important to extend conversations like this one beyond the purely intellectual into the realm of the affective and the performative. I do not think most of us know how to do this yet. But I hope that over the next decade we will learn to turn these events into programs that are appropriate to the task at hand. This will include the arts of literature, poetry, dance, and music. Without these, we will retain a kind of sterility.

## Reconstituting the Human Community

The top priority, then, is the reconstitution of the human community. The ultimate fate of the landscape will reflect the quality of the human community as defined through art, especially the art of ritual. The experience of restoration is possibly one of the most important bases available to develop a ritual tradition. Throughout your work and as it pertains to environmental restoration and management, think of yourself as contributing to the invention of a ritual to reconstitute the human community and integrate it into the natural landscape. ❑

# *PANEL: Decisionmaking and Priority Setting*

# *Identifying Biological Priorities in the Great Lakes Ecosystem*

Sue Crispin
*The Nature Conservancy*
*Chicago, Illinois*

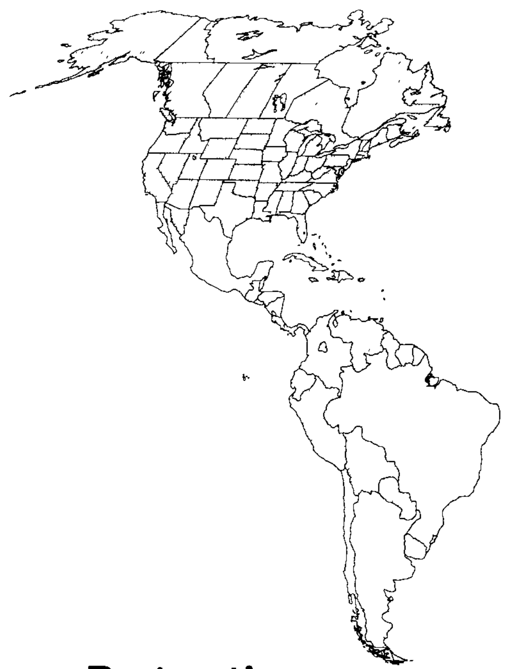
In the 1970s, the Nature Conservancy (TNC) developed the Heritage Program Technology as a priority setting system for biological diversity conservation. State-by-state teams of biologists working on these programs, inventoried the elements of biological diversity, their status, and locations.

These elements are fundamental but practical units for conservation; they involve two scales. One scale is the coarse filter that represents biological communities. If we could identify naturally occurring communities of species and protect examples, then we would capture most of the existing species diversity. The second type of element, the "fine" filter, is represented by rare species not consistently occurring in typical biological communities. Protecting both representative communities and rare species should capture all biological diversity represented in a landscape.

The Heritage program staff coordinates systematic inventories of these elements which show relative rarity and species endangerment in communities, globally and locally. They also show the quality of the occurrences to help protect the best or most viable of the most endangered elements. These inventories of biological diversity have been established throughout the United States, state-by-state, in four Canadian provinces and some 15 Latin American and Caribbean nations (Fig. 1).

This technology developed in the 1970s when TNC's focus was on buying land, or "habitat." After investing millions of dollars into the stewardship of biological diversity on preserved lands, however, it became clear that considering large-scale ecological processes on the landscape was important to secure indefinitely the biological diversity captured in land parcels.

**Figure 1.—The Natural Heritage Program and Conservation Data Center Network.**



## Process Restoration

TNC has become increasingly engaged in restoring ecosystem processes in order to conserve biodiversity. Our first efforts were directed at restoring fire and grazing to prairie ecosystems. Protecting and restoring ecological processes has also become important in conserving aquatic species, whose survival depends on hydrologic integrity.

Ultimately, protecting species and communities requires addressing the integrity of entire ecological systems, rather than simply securing habitat. The relationship of habitats to ecosystems is like that of seats on a jet airliner. Without the airliner providing structural support and powering the whole system, the seats cannot serve their intended purpose of carrying passengers. Similarly, ensuring the structural and functional integrity of ecosystems is fundamental to protecting species' habitats.

The Long Point Marshes on Lake Erie's northern shore are recognized both regionally and globally as an outstanding freshwater aquatic and wetland mosaic. A World Biosphere Reserve has been designated to help protect this area's outstanding coastal communities. However, sediments and pollutants draining from the watershed continue to negatively impact water quality in the bay and damage the communities targeted for protection. This example illustrates that conservation efforts must often be targeted at large-scale systems and processes to effectively protect key resources.

## Conservation Priorities

Prioritization is crucial because ecosystem conservation is complex, time consuming, and capital intensive. The Heritage data system guides TNC's targeting for ecosystem protection. Even though Heritage data are not collected and organized at the ecosystem scale, ecosystem conservation work is driven by the same biological criteria TNC has traditionally used to protect smaller scale sites.

In the Great Lakes Basin, using Heritage data to target biologically important ecosystems was especially difficult. The basin involves eight states and two nations. No Heritage data or inventory program in Ontario comprises 40 percent of the Great Lakes shoreline. So in 1990, with support from the Joyce Foundation, TNC undertook a two-year project to create a database for Ontario. It collected and added information on rare plants and animal species in quality communities to the Heritage database. The common database architecture shared by all Heritage database programs electronically synthesized that data into one data sack, allowing sorting by community site and species to determine regional conservation priorities.

Based on the regional information and the Heritage Data System, we identified three types of sites representing priorities for Great Lakes ecosystem conservation, emphasizing coastal, wetland, and aquatic areas because of their obvious functional relationship.

The first of the three areas contained concentrations of imperilled species—several to many of global significance in good quality habitat. The second priority was the best representative coastal community types—large, high-quality examples that reflect either the hydrological, long-shore, or microclimatic processes of the Great Lakes. This includes degraded but restorable areas if they represent the last of the type. The third priority was the best representatives of noncoastal wetlands—the largest, highest quality examples of wetland types up in the basin, representing communities or systems with major impact on water quality lower in the basin.

These areas are strategic for protection because they (1) represent reservoirs of biodiversity, (2) exist as models of ecosystem functions in places where the ecosystems still work relatively well, and (3) represent areas where degradation prevention is still possible and ecological conservation work has a low cost but high benefit.

Ecosystem protection includes ecosystem restoration because no site, at least in the Midwest and arguably worldwide, is still pristine. Even though conditions may still support rare species, some loss of function or process has occurred, with processes showing some corruption. Working at sites still in fairly good condition is valuable. By restoring processes in an earlier state of degradation, most conditions will self-heal because ecosystems are so resilient. This contrasts with highly degraded areas where major cleanup is required and restoration and reconstruction efforts are intense.

While restoration and conservation of high quality areas are cost effective, such areas in the Great Lakes Region are too numerous for effective simultaneous work. Since regional sites easily number 50 or 100, further strategic targeting is necessary to determine where best to focus efforts. Beyond identifying areas with concentrations of biodiversity, we must identify areas with the highest experimental value for ecosystem management and ecosystem restoration. Working closely with EPA, TNC is developing strategic considerations to guide project selection and work in the Great Lakes ecosystem.

## Strategic Analysis

First, we identified areas, described previously, where maximum biological diversity and ecological integrity can be restored and maintained for a relatively low cost. Areas targeted for early action should represent an array of ecological systems and processes so that the results of initial work will yield a broad spectrum of conservation knowledge and tools. Projects should also be selected to engage a wide variety of partners, in order to build new models of institutional cooperation.

Project areas should encompass various socioeconomic settings in which to test the local sustainability of conservation tools. Local project ownership is critical because local communities will be the long-term stewards of restored ecosystems. Finally, windows of political and financial opportunity will play an important role in project selection. Ecosystem conservation will be difficult, even at the easiest sites. Opportunities must be sought to move quickly and demonstrate short-term results that can pave the way for sustained, long-term commitment.

Individual project areas will need to be analyzed to identify stresses that threaten key ecosystem processes and components. Major causes of those stresses can then be pinpointed and conservation strategies designed to address stresses at their sources.

## Practical Technology Transfer

Ecosystem conservation strategies must be technology feasible, cost effective, and politically advantageous to make technology transfer practical. Even if we work at exemplary sites, select strategic project areas, and develop good ecosystem restoration and conservation programs, we must transfer successes to other sites in order to produce basin-wide benefits. This requires policy incentives coupled with funding incentives, institutional cooperation, and partnership, ensuring that similar partnerships occur at various sites. It also requires accessible information systems so that people, particularly local communities, have good access to information on ecosystem management and restoration. We have much to learn about transferring technologies effectively—this is probably the area most in need of new approaches and techniques. ❑

# Current Partnership Efforts in the Great Lakes

Charlie Wooley
*U.S. Fish and Wildlife Service*
*East Lansing, Michigan*

The responsibilities of the U.S. Fish and Wildlife Service (Service) are environmental protection in Michigan. It is responsible for wetlands protection and enhancement, endangered species, contaminants, and various Great Lakes programs. The following perspective is from a front-line ground pounder's viewpoint on hands-on, pro-active ecological restoration activities primarily in the Great Lakes or the Great Lakes Basin.

Three types of programs will be considered. One is an aquatic program based primarily in the Great Lakes, the second is a wetland program based throughout North America, and the third is a micro-wetland habitat. The first two programs are public oriented with government assistance provided. The last is very private, very personal—almost a private celebration of ecosystems restoration by private individuals.

## Preventing Ecological Destruction

The Service places high priority on preventing the need for ecological restoration. We like to prevent problems. Obviously, that does not always work. But we take a proactive view of ecological service activities, such as wetlands and habitat issues, throughout the country. That role is well known through the Endangered Species Act, particularly relating to the spotted owl in the Pacific Northwest.

We also have proactive ventures under the act that do not receive attention similar to the spotted owl. In the Great Lakes, we are receiving money for prelisting recovery activities. The Great Lakes sturgeon is a prime example. By some state standards, the species is endangered. It may be endangered by federal standards in a few years if we do not proactively work with the species and the ecological system that supports it. Thus, we put a lot of stock in prevention.

The Service's role in ecological restoration activities refers primarily to our "trust resources." Trust resources are defined as interjurisdictional and anadromous fish, migratory birds, wetlands, service lands, and certainly endangered species.

## Restoring the Lake Trout

An excellent example of ecological restoration that involves Fish and Wildlife activity is lake trout restoration in the Great Lakes. The Service decided that this was a high priority issue. It involves an interjurisdictional fish species present in the Great Lakes lakes that had declined over the last 50 years. The goal was to restore this species to a self-sustaining level in the Great Lakes and involves working with a healthy Great Lakes ecosystem.

These goals are not mutually exclusive. A healthy self-sustaining fish population goes hand in hand with an ecosystem approach within the Great Lakes. It includes interconnecting air, land, and water resources within the basin. Components or priorities are the physical integrity of the Great Lakes and protecting and restoring habitat within the basin.

The second goal was improving the chemical integrity of the Great Lakes by reducing, and in some cases eliminating, toxics that impact a particular species. And a third goal is improving the biological integrity or species protection and management where necessary.

## Integrated Management

Regarding the lake trout, along with a healthy Great Lakes ecosystems we also need "integrated management" of an exotic, which in this case is the sea lamprey. So we have an integrated approach to ecological restoration with the fish as the pivotal point in Lake Michigan. Numerous institutional stakeholders are involved in this process. Government has a role, as do the Great Lakes Fishery Commission, Canadian resource agencies, the private sector, and EPA. All are working to restore the system's ecological integrity, manifested in the recovery of lake trout.

We obtained information on one species—the lake trout—to provide an ecological or ecosystem restoration approach in the Great Lakes to benefit the species. We bring all the tools from our tool box to this issue, such as watershed management, pollution prevention, and natural resources damage assessment.

## A North American Problem

A second example is a North American problem—waterfowl and its relationship to the North American waterfowl management plan. This is the delivery vehicle to address an ecological restoration goal. We have a goal established by the United States, Mexico, and Canada stemming from a historical data base more than 50 years old that relates to waterfowl and, most importantly, to habitat. An important highlight of this integrity approach is working directly with the people who are responsible for managing the waterfowl and the habitat. Ecological restoration experts know that obtaining this goal knows no political boundaries. We have tried to seek out and address disturbances affecting North American ecosystems through numerous government programs here, in Mexico, and in Canada and developed with farmers and developers.

This partnership intertwines government, the private sector, developers, farmers, and agricultural interest in ecosystem restoration to the benefit of North American waterfowl, shore birds, and neotropical migrants. So from a simple goal of protecting waterfowl and increasing their population numbers comes a massive swell of people who want to make a difference through ecosystems restoration.

## Restoration at a Local Level

The third example is ecological restoration that occurs at a local level in someone's backyard, "back 40," or on their grandparents' land. This is a very personal linkage of people to ecological restoration. Approximately five years ago, a cooperative program was started in the north central United States involving a multitude of agencies and, most importantly, the private sector. Since then, agencies working through the private sector under ecological restoration guidelines have restored 12,000 separate wetlands for a total of 45,000 restored acres.

In working as partners with landowners and other segments of the private sector, we have concentrated on restoring drained wetlands to their original condition. We are not creating wetlands, but restoring wetlands on private property. The decisionmakers in this particular venture are not government bureaucrats—they are our constituents, the private landowners. And they are coming to us. They voluntarily pick up the phone and call the resource agencies or private conservation groups to express a desire to get involved in ecosystem restoration on their land.

Over the last two years, the tone has broadened from wetlands restoration to include prairie restoration on private lands. Some have even expressed interest in helping the endangered Indiana bat or Karner blue butterfly on private lands. This concept of ecosystem restoration comes from a huge program that relates to Canada, the United States, and Mexico. It is very meaningful for residents to buy in to wetland restoration and ecosystem restoration on their own private lands.

In many cases, these are the same people who drained their wetlands 20, 30, or 40 years ago. They have been educated about the value of wetlands. The scientists and experts have educated them through their teachings and writings and have created allies. In Michigan, people constantly call to ask for help with ecosystem restoration on their own lands. The people out in the field answering those phone calls and seeing things work are responsible for pushing these concepts and for providing the writings, teachings, and the students.

## DISCUSSION

■ **Question:** What is the status of Lake Trout restoration in the Great Lakes?

■ **Comment—Charlie Wooley:** The resource management agencies involved in lake trout restoration in the Great Lakes under the leadership of the Great Lakes Fishery Commission are optimistic that lake trout restoration will continue throughout the Great Lakes Basin. We are certainly on track in Lake Superior, and things are getting better in Lake Michigan. We are still barely holding our own in Lake Huron, though. Over the last 20 years we have seen a tremendous amount of progress. We still have some major obstacles to overcome in Lake Michigan and Lake Huron.

■ **Question:** How does water quality relate to lake trout restoration?

■ **Comment—Charlie Wooley:** We are pushing for an ecological restoration of water quality and habitat within a system that will support other species, but most importantly that will support the native lake trout species. We have had to deal with sea lamprey; if we do not, we will never be able to see our lake restoration goal occur in some of these areas. So again, it is a difficult front line—a roll-up-your-sleeves management question. But we are positive and confident that we can continue to see great progress in cleaning up the Great Lakes and increasingly better water quality. Lake trout restoration will begin the total ecosystems restoration.

■ **Question:** Are you continuing to rely on chemicals to control lampreys in the Great Lakes?

■ **Comment—Charlie Wooley:** That is correct, unless we can develop biological control, which is costing at least $1 million a year to develop.

■ **Question:** Will chemical control of lampreys continue as the only type of control over the next five years?

■ **Comment—Charlie Wooley:** That is a possibility, but foremost in the minds of the Great Lakes Fishery Committee is developing a biological control. Right now, we are involved in a massive sterile male lamprey program in which we actually sterilize male lampreys and put them back in the system. They spawn unsuccessfully with females and eliminate the population. So we are currently taking experimental biological control.

■ **Question:** Are people part of the Great Lakes restoration equation?

■ **Comment—Charlie Wooley:** At least in one sense, restoration will involve a continual subsidy or something similar to compensate for human influence that is simply unavoidable. This is because you cannot disengage from these systems.

■ **Question:** What is the incentive for people to become involved in wetland restoration?

■ **Comment—Charlie Wooley:** The incentive primarily is that people want to make a difference. The monitoring incentive is free to them. They call us, they call Soil Conservation Service, they call some of our partners, and we pay for it. We feel that the benefits of society certainly are much greater than the couple of hundred dollars' cost to involve people in the problem of wetlands restoration.

■ **Question:** Is the Partners for Wildlife Program found in Pennsylvania and New York?

■ **Comment—Charlie Wooley:** The program, Partners in Wildlife, is very successful in Pennsylvania and New York. Instead of the typical 1-, 2-, and 5-acre restorations that follow most development projects, these projects involve 10s, even over a 100-acre single restoration projects done for a few thousand dollars. They are restorations being done on formerly hydric soil, so the success rate is fairly high. It is really a great program.

■ **Question:** How about monitoring of projects after they are completed?

■ **Comment—Charlie Wooley:** The traditional, or resource agency, approach to wetland permitting and monitoring has been not to get involved in monitoring, declare victory, and move on to the next battle. That is changing. In central and southern Michigan, individuals are putting pressure on us and our congressional delegation to get money to monitor these programs. Throughout the country, we have selected key areas with ongoing monitoring programs. And we would like to continue to promise these land owners that we will monitor and tell them what is happening biologically in their backyards.

■ **Question:** Are any wetland restoration programs occurring in Indiana?

■ **Comment—Charlie Wooley:** They have a tremendous private land program in Indiana with, I would assume, some component of monitoring. It may be through the University of Indiana or one of the state or federal agencies.

■ **Question:** How long have some of these program restorations been developed?

■ **Comment—Charlie Wooley:** We have projects in Minnesota and Wisconsin right now that are approaching 15 years in duration.

■ **Question:** Do you provide follow up advice and support for projects?

■ **Comment—Charlie Wooley:** We offer technical support at any time over the life of a project. When landowners call, we have someone out as soon as we can to answer their questions. This is an opportunity to have our constituents supporting all sorts of wetlands, endangered species, and ecological protection programs. We do not want to lose a single person, so we strive to provide good support and service.

■ **Question:** What about the impacts of nonregulatory programs?

■ **Comment—Charlie Wooley:** Enough nonregulatory funding and projects are coming out of an agency like EPA; particularly in nonpoint source, I hear a lot about nonregulatory programs trying to help states get their programs in line. This is to encourage rather than adhere to regulations. EPA and other regulatory agencies have a lot of nonregulatory options, particularly in after-the-fact permit decision. A lot of data has been collected on how permits are issued but much less on how many actually go through the process.

■ **Question:** How can you tell that you are actually restoring an area that was formerly a wetland?

■ **Comment—Charlie Wooley:** First, we must look at our historical data base. On our National Wetland Inventory maps, we want to identify current or former wetlands. So before we even leave the office, our biologists have an idea, based on data, whether we are looking at true drained wetland or dealing with someone who wants a bass pond in the backyard. We don't do bass ponds; we do wetland restorations.

Before we go out in the field, we determine if we are looking at hydric soils; if so, we go onsite. If, based on soil sampling, we think we can turn a site into a wetland restoration, we meet with the land owners; we tell them what is involved. If we can go forward, we find out how much land is available and whether they can keep the land in a wetland state for at least 10 years. They must sign a document to that effect. We concentrate on hydric soils and areas that have been drained.

■ **Question:** Do land owners have to sign any type of easement for this program?

■ **Comment—Charlie Wooley:** We need an easement signed by the landowner for another 10 years. We have some in perpetuity but most are just 10-year agreements. In Minnesota, Wisconsin, and the Dakotas, once people restore the wetlands and see the benefits, they do not want them drained. And more importantly, their children and grandchildren do not want them drained either.

■ **Question:** Are you involved in any type of prairie restoration?

■ **Comment—Charlie Wooley:** The prairie restorations that we are starting to develop—a little bit in Minnesota, some in the Dakotas, and in the southern part of Wisconsin—are based on prairie plant species. We are not building bass ponds or providing a food plot for someone to hunt quail on their back 40. Prairie restoration is done with certified seeds and professional advice, considering what was there historically.

■ **Question:** How can EPA become more involved in assisting the Fish and Wildlife Service in ecosystem restoration?

■ **Comment—Charlie Wooley:** If we are using similar targeting criteria and procedures, we will end up helping each other. EPA can provide leadership in directing the course of ecosystem restoration and conservation, not only within this region but nationally; not only through the regulatory power, but more importantly through its funding power. EPA can require that ecological restoration take a true broad-based ecosystem perspective.

While working in a narrow geographic level and on a particular project is easy, EPA can compel us, as it is doing with The Nature Conservancy, to look broadly at ecosystem stresses so that our work has transferability. It can also help and compel us to effectively transfer it. That is one of the biggest challenges on the horizon, to figure out how to transfer technologies to other areas.

■ **Comment:** Region III in Philadelphia is attempting a terrestrial habitat restoration initiative that goes way beyond its water quality jurisdiction. Is this region thinking along the same lines, or attempting that? Do they have the justification to do what they are doing?

■ **Question:** Are we going to have to take a different approach to dealing with people on these type of issues in the future?

■ **Comment—Charlie Wooley:** We are talking about a different approach, a different posture between the human community and the environment, and it suggests a different kind of relationship between elements of the human community as well. In the future, we may not need to think so much about regulation, about keeping bad guys in line. People just want to do this. What's their incentive? Now we have the outline of that kind of relationship with nature. EPA, which grew up in the '70s and had to build some walls around precious ecosystems, may now begin to be an advocate. One thing EPA may do is get more involved in education. ❑

*PANEL: Decisionmaking and Priority Setting*

# *Approaches to Ecological Restoration*

Robert P. Brooks
*Pennsylvania State University*
*University Park, Pennsylvania*

We do ecological restoration for a number of reasons. The first two reasons—the legislative mandate and the health and safety issues—are mandatory, things we cannot avoid. We are guided by the regulatory compliance on a specific site, an immediate need to respond to an emergency, and other instances. These get done whether we plan for them or not. The voluntary areas are where we need to discuss how to get projects started and build constituencies to help us.

## Coordination Levels

Projects in different categories require a different level of coordination (Figs. 1 and 2). In the mandatory category, for example, the Endangered Species Act requires a recovery plan for individual species. It is very specific on how plans are constructed. The Surface Mining Control and Reclamation Act fortunately requires reclaiming the mining landscape. However, because it is driven by specific regulatory guidance, little flexibility is permitted.

For health and safety, issues include an immediate threat to the community water supply, a hazardous waste spill, or a landfill leakage. These situations receive immediate attention.

Research is usually driven by some kind of hypothesis that we want to test. A book edited by William Jordan discusses using ecological restoration projects to test scientific hypothesis.

For educational projects, many have tried to encourage a demonstration site, show the technology for a particular watershed, and get other people to buy in to build a larger constituency. Community-based projects are increasing. This is necessary since the scope of restoration needed cannot be funded from the government's pocketbook. We must involve people—large public groups, special interest groups. Usually, people have some particular interest; then they decide to get organized and get involved. The project may be a cleaning up a river system or a park restoration.

## Coordinating Within a Regional Landscape

The area that is most difficult is looking at a regional landscape and trying to coordinate multi-group actions, multiple agencies, and nongovernmental organizations. We are working towards major watershed protection—like the Chesapeake Bay or the Great Lakes area. We are trying to link major habitat corridors across the landscape, involving both public and private lands. These are extremely difficult to coordinate and to get everyone thinking along the same lines.

Administrators are familiar with strategic planning: Why are we doing this restoration? What are we going to do? How are we going to focus our goals into specific objectives? Starting with a small informal group to hammer out issues is preferable. Some feel that the public meeting process is a better approach to get all the interest groups on board and reach agreement. But for larger scale restoration projects, this is difficult. This situation needs a small technical group—some policy people, some technical people—talking and defining the agenda before it goes before the public. Without this, the project will be difficult to sell. Complex projects require many back and forth iterations to determine how much can be done and what procedures to use and to define specific goals, objectives, and targets for restoration.

## Getting Operational

Just as administrators are familiar with strategic planning, managers are familiar with how to get projects operational: how to accomplish specific things like timetables, deliverables, construction

**Figure 1.—Reasons for engaging in an ecological restoration project.**

INCREASING NEED TO COORDINATE ↓

| IMPETUS | EXAMPLES |
|---|---|
| LEGISLATIVE MANDATE | ENDANGERED SPECIES<br>MINE RECLAMATION |
| HEALTH / SAFETY ISSUES | THREAT TO WATER SUPPLY<br>HAZARDOUS LANDFILL |
| RESEARCH / EDUCATION PROJECT | EXPERIMENTAL PLANTINGS<br>SCHOOL DEMONSTRATION AREA |
| COMMUNITY CONCERN | RIVER CLEAN-UP CAMPAIGN<br>MUNICIPAL PARK RESTORATION |
| REGIONAL INITIATIVE | WATERSHED PROTECTION<br>LINK HABITAT CORRIDORS |

**Figure 2.—Differences in rationale and approach for ecological restoration projects.**

INCREASING NEED TO COORDINATE ↓

| IMPETUS | TARGETING GUIDANCE |
|---|---|
| LEGISLATIVE MANDATE | REGULATORY COMPLIANCE AND CRITERIA<br>SITE SPECIFIC |
| HEALTH / SAFETY ISSUE | IMMEDIATE RESPONSE VS LONG TERM REMEDIATION |
| RESEARCH / EDUCATION PROJECT | HYPOTHESIS,<br>TARGET AUDIENCE |
| COMMUNITY CONCERN | AD HOC INTEREST<br>NEED FOR TECHINICAL EXPERTISE |
| REGIONAL INITIATIVE | SCALE AND COST MANDATES<br>INTERORGANIZATIONAL COORDINATION |

equipment; deciding who is going to pay; what kind of methods to use; who is in charge. That is where the organization comes in. Whether the project is a two-acre restoration or a watershed, having a key contact person is critical.

Monitoring and evaluating wetlands must be discussed. How are we going to assess the project? What are our criteria for assessing success and failure? Monitoring and evaluation should be an explicit part of any restoration project, complete with deliverables, and not be confined to the project report for the file. Coming up with ecological milestones or thresholds or measures of success is sometimes difficult. But useful ways to do this exist.

If we expect to have large-scale restoration, we need to share our information—not only with the technical and policy people, but also the public—to encourage involvement.

## An Ecological Sandwich

Restoration is an ecological sandwich. You must deal with the various layers—physical, biological, and cultural—that are part of the system and pertain to a particular project restoration site. Every site has a landscape position. Too often, we only see the consequences of site-specific restoration projects. An ecological sandwich allows you to position the project in a landscape setting. Where is it? Did you look around? Did you look beyond the boundaries? What are the inputs to the system? What are the seed sources? Who is the constituency? Who are the supporters of this project outside the project area? Maintaining the landscape perspective is important for any project.

In order to be successful and build support within organizations and the community, tackle problems that have real solutions. Avoid setting yourself up for failure by trying to achieve something that is decades beyond where we are now. Look toward that, but set some intermediate goals along the way. This means establishing small projects that are somehow integrated, either physically or from a management perspective.

## Passion in Policy

And the last question: Is it possible to have passion in policy? To be successful, restoration must include a certain amount of passion from those involved in the day-to-day project management and those that see it to final conclusion. The Curtis Prairie was not started because somebody thought, "I'll just try this for a day." They were passionate about getting that project started.

## DISCUSSION

■ **Question:** How does a restoration project begin?

■ **Answer—Robert P. Brooks:** There are starting points. In some cases, a couple of citizens sitting around the dinner table or meeting in the park can be the source, the beginnings of a project. In talking with some agency people in Harrisburg about a park needing restoration, one problem was traffic from one township driving through another township. While this was a safety issue, another aspect was park ownership. I suggested that citizens in the two townships talk to each other—they thought that was hysterical. These were different townships with different economic levels. However, unless the people started talking to build intertownship support, they could not proceed on an particular issue.

There are many ways to get started. You can start with a piece of regulation that demands that a site be restored. You can start with community grassroots, or you can start with a broad-based regional approach involving agencies, organizations, and the public. All are equal.

■ **Comment:** Something remarkable is happening in the restoration world. A major restoration project, for example, in Central Park in New York City is being driven to a considerable extent, plan by plan. Politically, this is a very complex situation.

■ **Question:** When the citizens' perception of where the problem is or where the work should occur differs from the professional agency or restoration people—when citizens rise up and want to work on an area—that draws resources and the agency responds. Most of us in the public sector translate that as taking resources from somewhere else. How do you reconcile this?

■ **Answer—Robert P. Brooks:** I will turn that around and ask the collective audience to answer because I do not have a candid answer. Any suggestions?

■ **Comment:** We have some experience with that at the Arboretum through volunteer groups. The Arboretum has always been a professional operation—we make decisions and hire a crew. In the last few years, we have begun turning projects over to the public. We were immediately concerned that the projects would be ruined. The public's idea of what a project requires is not the same as an ecologist's.

However, this has not turned out to be a problem. A year ago, we had neighbors enraged about a project that required cutting brush in an area that served as a thick screen. They were angry and swore in meetings. In the year since, with just a little bit of gracious response from our staff, one person in particular who was the noisiest is now a master restorationist on that project. And so, who won? Everybody won.

I have very limited experience; there are people with a lot more. Sue, can you address this in connection with the work around Chicago with Steve Packard's group? They have 4,000 or 5,000 volunteers working and are finding that they get smart. Sooner or later, they get smart. They also teach the experts something.

■ **Comment—Robert P. Brooks:** For conflict resolution, you need to look at the educational aspects in your bag of tricks. You go to the leadership of competing groups and get them together. There will be compromise and learning both ways; you just try to resolve this and focus energies toward the real issues and not the squabbling.

■ **Comment:** You also need to let people make little mistakes. They are better off making a mistake and then they fix it later . . . .

■ **Question:** I can put you in touch with 20 people with extensive experience in this area. Monitoring has come up several times; I always hear monitoring brought up in this kind of dutiful way: "We have to be sure to do a monitoring; monitoring is really important." I sense that people do not do monitoring for a reason; or when they do it, they do not use the results.

People love to get out and plan or tinker around with the grade or bring water back in where it has been excluded. And then you get into this monitoring. Is it boring? Or what is it?

■ **Answer—Robert P. Brooks:** I think it is fun, actually. I have found agency cases often have no budget because it was not put on the table up front. Particularly with construction projects, whether a transportation agency or major subdivision, the project ends and therefore the budget ends. We do not have monitoring money for five years. So we need a pool of money or a well-organized volunteer network. You need to specify that as an early objective in the planning.

■ **Comment:** The interest taken in monitoring will depend on the clear perception of the project and defining a context for the monitoring so that the result is not just numbers. If I know why I am taking a Secchi disk reading every week and that it will produce some really useful information, then I probably will have a greater incentive to do it. Is that part of the problem?

The projects are set up in a restoration ecology sphere. They say: "We are going to test sediment rates, or nitrogen cycling recovery, or nitrogen recycling system. We are guessing that certain parameters are critical. We have done an experiment here. We are really curious to know what becomes of nitrogen cycling in this system."

■ **Comment:** I think that can inspire some volunteer monitoring. But generally the people footing the bill explicitly state the objective. As far as monitoring, they don't care. They will have to pay for it; it is just another cost. Let's get it done as quick as possible. But I do think that is an aspect that should be included.

■ **Comment:** Might it be that kind of policy is backed up by the attitude that once we have restored a system, then it is up to nature? We do not have to do anything more with it. ❑

# *PANEL: Using Existing Authorities More Effectively*

# PANEL: Using Existing Authorities More Effectively


Bertram Frey
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In this panel, each panelist will briefly introduce a topic—hopefully, a controversial one, after which the other panel members will respond. The four topics to be discussed are as follows: (1) Why are ecological restorations taking so long? (2) What are the tools to accomplish restorations? (3) How can EPA do a better job in coordinating its restoration efforts with other federal agencies? (4) What approaches can agencies take to ensure that restoration will provide maximum benefits to the environment?

## PANEL DISCUSSION

■ **Question—Bertram Frey:** Why are ecological restorations taking so long?

■ **Answer—Wayne Schmidt:** The quick answer is we wish we knew. No one argues that areas in the Great Lakes need restoration—we have waited long enough for cleanup to begin, so why aren't the dozers and the draglines out there today making progress?

Talking to this diverse audience is a special privilege, particularly the cross section of EPA staff, including the Great Lakes National Program Office. Whatever our disagreements over programs and priorities and no matter how many times we may sue EPA, we do not question your individual commitments to restoring our environment. The public owes you its thanks.

Our primary interest at the Great Lakes Natural Resource Center is in large-scale ecosystems restorations; our main focus is on Great Lakes aquatic systems. While prevention is an equally important component, we have other programs to deal with that. We are interested in restoration of areas that make a difference—like the benefit of regional species diversity and richness, continental waterfowl populations, and others. The benchmark for restoration progress in the Great Lakes are those 43 areas of concern identified by the International Joint Commission of the United States and Canada and noted in the Great Lakes Water Quality Agreement between the two parties.

For example, in the Detroit River—an area near where I live, boat, and fish—50 percent of the endemic fish species are gone. Grassy Island in the downriver area, part of the National Wildlife Refuge, has been a dumping ground forever. The woodcock on the island have some of the highest levels of contaminants found anywhere. The answer is really quite simple. Stop the input of bad stuff going in, clean up the gunk at the bottom of the river, allow nature to restore that substrate, get the wild celery and the *Hexagenia* growing again, and the diving ducks will return.

Our objectives are defined by the Great Lakes Water Quality Agreement. Its purpose is to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin ecosystem, as well as the objectives in the Clean Water Act. A good share of our criticisms for the slow pace of progress is directed at EPA. The EPA gets the largest share of the funding for these programs and bears the largest share of legal responsibility.

Some of you may not like or find fair my comments throughout the panel discussion. They may seem harsh, but they do represent a consensus of a number of our colleagues. Despite piecemeal progress, Great Lakes ecological restoration is stalled.

Before this meeting, I tried to get a candid assessment of how people around the area felt. People close to the Grand Calumet remedial action plan assessed it as "a farce." Regarding the Kalamazoo River remedial action plan—the Kalamazoo River and the Grand Calumet are two of the most egregious sources of PCBs to Lake Michigan—"little progress." What about the Lake Michigan Lakewide Management Plan now under review? The candid assessment is that it should be written over again; it is nearly worthless for what it was designed to accomplish.

EPA cannot do or fix a lot of things. But two things are lacking that can be remedied. One is leadership and a commitment to restoration from the top down. We do not think it is there. We see a major inertia on a commitment to Great Lakes' ecosystem restoration. Second is a very precise blueprint for restoration. Who is going to do what? What is going to get done? Where will it get done? How much will happen? And when will it happen — load reduction strategies, deadlines, and milestones?

■ **Comment—Bill Kruczynski:** I am happy to see that we are addressing the same issues all over the country. I come from Florida and work out of the Atlanta office. We have the same issues talked about this morning—the same issues Wayne brought up—about things not working the way they should. Getting anything done takes so long because of the many special interests to be appeased. That boils down to the word "politics" in allocating funds.

We have been trying to start a program in the southeast called the Gulf of Mexico program, which competes with the Great Lakes program, the Chesapeake Bay program, and every other program in the country. And if it were not for a group in Congress—"The Sunbelt Caucus"—that program probably would not have gotten to first base. This points out that with a limited budget, everyone is competing for the same resources.

Another problem is too much fragmentation of authority and reluctance to create another government entity. However, we may need some sort of national oversight for restoration.

■ **Comment—Bertram Frey:** Wayne raised four points. We should focus on areas of concern in the Great Lakes—I think we have—and that the Region V Great Lakes National Program office is not really focusing on great areas of concern. I would disagree. He attacked remedial accomplishment plans (RAPs) for northwest Indiana. The RAPs are the states' prerogative and they have the lead.

In responding with what we have done in northwest Indiana, I head up an enforcement initiative centered in southeast Chicago and northwest Indiana. We are restoring probably the last dead river in the Great Lakes Basin—the Grand Calumet—which is a river running through the sand. The Little Calumet is the southern river, and the Grand Calumet is the northern river.

Our enforcement initiative is part of a broader initiative to address a whole host of environmental problems in northwest Indiana. One concern is floating oil. One area contains 15 to 17 million gallons of petroleum distillate floating on top of groundwater. We are certainly trying to address that. We are also addressing sediments in the Grand Calumet. And we are trying to set our goals. By 1996 my goal is to reduce environmental toxic loadings by 50 percent through enforcement and other means.

The enforcement component, particularly on the Grand Cal, is to sue everybody. You name a site, we have an ongoing action. We have settled with the city of Gary, which calls for penalties of $1.25 million to comply with the Clean Water Act. The settlement also calls for some sediment remediations, the cleanup of the Rallston Street Lagoon adjacent to the Grand Cal and highly polluted with PCBs. We have a major suit against Bethlehem Steel, of which we have settled part. We had a case against USX Gary; the decree called for a $34 million package to get sediment remediation and toxics out of the sediments. We settled a case with LTV, whose property is adjacent to Inland Steel's property. LTV committed to spending roughly $10 million to remediate 10,000 pounds of sediment from the bottom of the Grand Cal.

In the Indiana Harbor area, we have done a multi-media inspection of Amoco. We have a case against Federated Metals, recently settled for some $675,000 in penalties. Each matter has resulted in significant penalties; we have exchanged some of the penalties for valuable injunctive relief or supplemental environmental projects. The planning for the RAP for this area may not be as far along as it should be. But federal and state governments are doing much to clean up and restore some of the very heavily polluted areas of the Grand Calumet River.

The third salvo was a concern that our lakewide area management plan, particularly for Lake Michigan, is not out yet; therefore, it is hard to criticize before it is final. I would strongly disagree with the characterization that the plan is worthless. On the commitment to restoration throughout the lake, the Great Lakes National Program office is developing a five-year plan. That plan represents a fundamental commitment to restoration in the Great Lakes.

The Great Lakes Critical Programs Act, by statute, gave EPA a schedule to promulgate the Water Quality Guidance and other documents. The principal objective is to develop uniform, stringent, and scientifically defensible water quality standards throughout the Great Lakes Basin. It also has other objectives like antidegradation goals. We are behind schedule, but we are also under court order to get something out by April 15. We have resumed the course to accomplish that. My office has recently defended five suits against the National Wildlife Federation.

■ **Comment—William G. Painter:** I am not involved in all aspects of the Great Lakes programs, but it is sobering to hear Wayne's comments. From my perspective in Washington, the Great Lakes is one of EPA's flagship efforts to restore the entire ecosystem. And former EPA Administrator William Riley made it clear that this is important to him. I wonder what that tells us.

Obviously, the agency could do more with more people and more courage. In thinking about the people in the Gulf—you are where they were in the Great Lakes 10 years ago. It almost makes me want to give up and go open a fishing camp.

■ **Comment—Wayne Schmidt:** First, whether you agree with that assessment or not, I think it should be sobering. The fact alone that the perception exists is sobering. Second, I refer you to a report from our office called "A Prescription for Healthy Great Lakes," done before I worked there. It lays out the specificity and a strategy needed for the type of ecosystem restoration we are talking about. Whether or not you agree with the specifics of the plan, it outlines the elements needed.

■ **Question—William Painter:** But what does this tell us about the possibility of doing things on the scale of the Great Lakes, or the Chesapeake Bay, or the Gulf of Mexico to anybody's satisfaction. Or will we have more success in dealing with smaller places?

■ **Comment—Bill Kruczynski:** Before you open a fishing camp in the Gulf of Mexico, you ought to give us some money to get some fish back. We have serious habitat loss problems there, which I will discuss later.

■ **Comment—Jim Giattina:** I have been providing assistance through EPA to certain states that have opted to go through the watershed protection approach—North Carolina, Washington, and Delaware. They are making great strides to bring together different parts of research programs to come up with national research management on a watershed basis. So, the agency is contributing in areas other than the Great Lakes.

■ **Question—** Has EPA actually collected any of the penalty money that has been imposed for violations along the Grand Calumet River?

■ **Answer—Bertram Frey:** We have gotten some checks from a federal consent decree. That is, after all, a judicial order. The date in those orders has passed; they sent the money.

■ **Question:** What is the money being used for?

■ **Answer—Bertram Frey:** The money for penalties goes to the treasury. But in many cases, we have negotiated far more in supplemental environmental projects or injunctive relief. In the USX case, for example, the penalty was a relatively small fraction of the $34 million the company must spend to clean up sediments, as well as cleaning up discharges at the plant.

■ **Question:** When are they supposed to start doing the study?

■ **Answer—Bertram Frey:** USX has done a study to characterize a lot of the sediments. Quite frankly, the situation is far worse than we originally had thought. Our authority to proceed rests on certain regulations like those promulgated under the Toxic Substance Control Act (TSCA). PCB problems are bad in some sediment hot spots. We are now talking to USX about additional violations as well as additional restoration in that area. It was a part of $7 million for sediment remediation that includes some for these studies and for actual sediment remediation. That is digging them out of the Grand Cal and removing them so they do not pollute the lake for another 50 years.

■ **Comment:** The big problem is that the Army Corp of Engineers has been studying the lower portion of the Grand Calumet River, called the Indiana Harbor Canal, for about 20 years, on and off. They do not know where to put the stuff once they dig it up. Everybody knows it must come out, but no one knows what to do with it. It continues to sit there, and no telling how much longer it will continue.

■ **Comment—Bertram Frey:** That is an apt criticism. The ECI site in northwest Indiana was a closed site, previously owned by ARCO and then ECI, and presently owned by East Chicago. The site went into bankruptcy. We have filed a claim for a $30 million pot of money in the bankruptcy. The government would get first priority to clean up the site. If we could use a substantial portion of the money to clean up the site, we might be able to create a combined disposal facility for the dredged spoil from the Grand Cal projects.

We have not just sued USX; we have also sued Gary, Hammond, Inland Steel, LTV, and Federated Metals. We need to put the dredged spoil from a whole number of projects somewhere. That is a key barrier that I do not want to underestimate. Putting it in the proper site and treating some of it before we put it in the site are both key issues.

■ **Question:** On the Great Lakes, we have seen the first level of system recovery in response to phosphorus control. We have seen the species composition shift and the great response. In some places, like Green Bay, that recovery is not yet complete. Remediation still must be done.

Wayne is absolutely right when he said recovery is slow. Recovery from toxic substances is going to be decades long. Is it proceeding fast enough?

We must have a layer to review these things. The final ecological recovery is very distant. How can we find measures that reliably explain to the public and measure success over a period of time? That is the question I have for the panel. Can you identify a means in restoration to realistically mark the steps in recovery so that we do not leave people frustrated when we know some kinds of recovery will take 20 to 30 years?

■ **Comment—Bertram Frey:** One of scientists on the panel should answer that question. Measures of success will be covered by a panel or two later on. I do not know whether that is our primary charge, but we will answer that question as best we can.

■ **Comment—Bill Kruczynski:** I have dealt with that for years in trying to establish some sort of standard for success criteria for different ecological systems. I cannot speak for the Great Lakes, but we have come up with standards for phosphorus mining in forestry systems in Florida. We must sign off on those as being acceptable without waiting for them to become self-reproducing systems. So, at a point in the continuum from time zero to 40 years, we must say that enough has been shown to think this has a good probability of success. The standards that we have used to achieve this, for example, are 400 cypress trees per acre and 70 percent ground cover over a couple years, maybe two growing seasons. Seeds are being produced by at least 5 percent of the cypress trees by year five, or year 10 for deciduous trees. Cypress trees will put out some seed balls in five years.

A 1 percent accumulation of organic matter in soil would be approaching success. There is some accumulation; it is not all burning away. The hydrological components are very difficult to measure, unless we can measure them against a "referenced" wetland. So you need reference wetland forested sites to show that the timing, frequency, duration, and height of the water that comes up on the site is similar to your reference site. So we must put some time and effort into developing standard success criteria.

■ **Comment—Wayne Schmidt:** One interim measure of success is when the bald eagles on the shores of Lake Huron and Lake Michigan successfully reproduce and sustain their populations.

■ **Comment—Bertram Frey:** Another might be the number of fish advisories for any of the lakes.

The second issue is what are current legal regulatory public policies to accomplish ecological restoration? Since I am a lawyer, I am focusing more on command and control—the narrow part of the equation. Is the scope of those tools effective? Are they sufficient? Are new laws, regulations, policies, or programs needed? What level of authority is most effective? Are state, federal, or local authorities dealing with ecological restoration?

I have tried to show in the laws (see Appendix following discussion) where restoration is either a key goal or something used to force a private party or governmental agency through command and control. If you look at key parts of the Clean Water Act, the principle objective is to restore and maintain the chemical, physical, and biological integrity of waters in the United States. That is echoed in the International Joint Agreement for the Great Lakes Basin that Wayne mentioned. In particular, you can restore wetland and enforce a violation under a 404 permit, whether it is illegal discharge without a permit or violation of a permit.

Without a permit, EPA will enforce; the Corp of Engineer enforces the violation of a term of a permit. One of the key goals in the 1990 amendments to the Clean Water Act, in particular the Great Lakes Critical Programs Act, furthers the goal of maintaining the chemical, physical, and biological integrity of the Great Lakes Basin waters. The requirements for implementation of both the RAPs and lakewide management plans (LAMPs) specifically mandate the development of documents in an organized, systematic, comprehensive, ecosystem approach to restoring and protecting beneficial uses of waters, both in the case of the LAMPs and for designated areas of concern in the case of the RAPs.

Another effective law is the Superfund law. We have many powers to remediate sites. We can clean up sites and send liable parties the bill. For restoration goals, I want to focus on cost for natural resources damage, the principal issue in the Exxon Valdez. The lawsuits will drag on for years, but resource damage is the largest cost at a lot of our sites.

With hazardous substances at superfund sites, and in many cases of oil spills on the water, the greatest cost is restoring natural resources damages. The measure of damages for natural resources is the cost of the past damage or the cost of restoration, whichever is greater. That is clearly an authority we can use to pursue ecological restoration in conjunction with the superfund sites in northwest Indiana.

The key to using that law is doing the assessment. The Fish and Wildlife Service is generally the trustee for fish and wildlife. States are usually trustees for sediments. The problem is that they do not have money to make a good assessment, so we have more difficulty claiming natural resource damages as part of a superfund action either for enforcement or cost recovery. The Oil Pollution Act, newer than the Superfund, even better addresses the cost of restoring, rehabilitating, replacing, or acquiring the equivalent of the (1) damaged natural resources; (2) the diminution in value of those natural resources, pending the restoration; plus (3) the reasonable cost in assessing those damages. So we can get all those back in response to oil spills directly under the Oil Pollution Act.

We have already discussed the Great Lakes Water Quality Agreement and its principle goals. You can look at some of the other legal authorities, but they are inadequate. For sediments for example, a pastiche of authorities address sediments—the Resource Conservation and Recovery Act (RCRA), the Water Act, and Superfund. No laws are tailored to effectively deal with ecological restoration on a river basin, let alone a larger ecological system. I want the panel members to address some present regulatory public policies that are effective or where new laws are needed.

■ **Comment—William G. Painter:** EPA's policies are not. But I don't think the answer is to give EPA new authority to enable us to do the job from soup to nuts. We have a lot of other federal agencies, state agencies, and private organizations with a great deal more experience in certain key aspects of ecosystem restoration than EPA has or should ever have. On the other hand, EPA is starting to realize that, generally, addressing chemical contamination will not achieve full ecological restoration—physical, chemical, and biological integrity. We are doing well on the chemical integrity, but we do not have the ability to address some of these other areas. Therefore, how can EPA work more effectively with other organizations that have greater expertise in the field?

Several things were not brought up here—in particular, money. We have a state revolving loan fund program. The federal government is still putting about $2 billion a year into capitalization grants to allow states to make loans to municipalities and others for programs. Up to now, most of this money has gone into building sewage treatment facilities. But you can fund projects under a state section 319 nonpoint source program that can include stream and wetland restoration. You can fund projects in a national estuary program, which is not so relevant to this region as it is to other parts of the country.

If the Clinton economic stimulus goes through, $47 million in supplemental money will be available in the current fiscal year. The money would run through the section 319 nonpoint source program. EPA sold this to the White House by painting the image of people restoring streams and wetlands, planting things, and moving rocks around. The White House does not want to see the money go into developing nonpoint source plans or similar things.

Another tool that has hardly been tried is point/nonpoint source trading. This involves a municipal sewage plant that, instead of spending money on removing point source pollution, puts money into nonpoint source controls for agricultural and similar activities. This is an attractive idea because the costs are usually less for nonpoint source controls than for advance wastewater treatment. In at least one place, EPA is allowing the community to restore the stream channel and the riparian zone instead of installing the advance wastewater treatment.

And as a result, we will not only solve the water quality and chemical problem, but we will see a greater restoration of the entire biosystem than if we had just, in this case, cleaned the ammonia, leaving in place a denuded riparian zone and a degraded stream channel. Clayton Creager will talk more about this. But this is another area of EPA authority to explore.

■ **Comment—Wayne Schmidt:** Obviously, the program has holes. It would be nice to fill them. The lack of natural sediment criteria has to hurt its efforts. It is unacceptable, but we may have to live with the fact that we are three years away from proposed criteria for PCB sediments. In Region V, we may need regional sediment criteria for chemicals of concern, similar to the proposal for wildlife criteria in the Great Lakes Water Quality Initiative.

Obviously, the Fish and Wildlife Service Great Lakes Restoration Act program needs help; we are responsible for helping as well in the natural resource damage assessment program. In its history, the program has only recovered $27 million nationwide. Nevertheless, this is not an excuse for delay. We think adequate authority to proceed is in the hands of the various agencies, particularly given the Great Lakes Water Quality Agreement, Great Lakes Critical Programs Act, and the possibility for "creative administration" of existing authorities.

We are happy the Great Lakes Water Quality Initiative is moving forward. Last week in Chicago, a meeting explored Region V's next phase of the bill. The Great Lakes Toxics Reduction Initiative has great potential, but we are uncertain about whether that potential will be realized. But for example, Bert talked about this pastiche of programs dealing with contaminant sediments. This initiative can potentially bring some focus, some forum to that pastiche and provide the integrating measure necessary for an overall strategy for moving on with some of these programs.

■ **Comment—Bill Kruczynski:** In my experience, restoration programs are performed quickest and done best if they are managed and implemented locally by local agencies, cities, counties, or state governments. In Florida, we have water management districts that manage the watersheds. If we can convince local authorities that a restoration effort is needed in a particular area, the districts are likely able to quickly sell this to local politicians, developers, or to whomever needs to be sold locally, because they are in touch with them. So I am a firm believer in watershed restoration at a local watershed level.

However, the overseer should be someone who develops goals and prioritizes the areas to be addressed. We are not the first to discuss this. A book entitled *Restoration of Aquatic Ecosystems* was published recently by the National Research Council. Dan Willard is one of the authors. The book discusses this issue and proposes developing a national aquatic ecosystem restoration unit or team to oversee restoration efforts throughout the country.

I am not one to propose new governmental entities, but because of the fragmentation and the historic conflicts between agencies, with each stepping over the others' turf, perhaps we need some new oversight committee to prioritize and implement restoration at the national level.

■ **Question:** The list passed out (see Appendix) has one glaring omission—the Conservation Reserve Program. Reports indicate that the program has reduced the sediment input to streams and waterways by some tremendous percentage—possibly 50 percent. Can someone comment on the program's effectiveness? In some sense, it may be more directly relevant to restoration, the landscape level, and other things we have talked about.

■ **Comment—Don Butz:** The Conservation Reserve Program has been in effect for about seven years, with 36.5 million acres currently enrolled in the program throughout the United States. I cannot give specifics about the Great Lakes Basin, however. In erosion control, we have reduced soil loss approximately 700 million tons per acre annually; that equals approximately an annual 19-ton-per-acre reduction on each acre enrolled in the program. A considerable amount of this is sediment reduction—over 200 million tons of sediment reduction in the program.

■ **Comment—Bertram Frey:** EPA has worked with the Department of Agriculture through the county agencies in many programs for erosion control, which may be considered restoration. Erosion control is preventing the soil from washing away down our river systems. The Department of Agriculture does that much better than EPA.

■ **Question:** Are the stream sod filter strips eligible to be included as enrolled acreage? How much of that is going on? Do people know what having acreage enrolled means? Does everybody here know that, or does somebody need to explain? What happens when you enroll acreage?

■ **Answer—Don Butz:** Enrolled means that private land owners voluntarily bid their land into a 10-year program and accept a certain dollar value for renting the land to the government. They agree to take a part of the land that was originally in crop production and put it into a long-term vegetative cover—grass or trees. After 10 years, the land can go back to whatever the landowner has in mind. This is another issue that needs to be addressed in the next farm bill.

Buffer strips, or filter strips, can be enrolled in the program. They are strips of land along rivers, streams, or lakes that also can be placed in vegetation to help reduce the loadings flowing into streams, rivers, and lakes. Buffer strips are a kind of protection strip placed in the program for 10 years.

■ **Comment—William G. Painter:** How can EPA do a better job of coordinating its ecological restoration efforts with other agencies that have expertise and resources in the field? Obvious candidates would include the Fish and Wildlife Service, which under the Clinton economic package would receive millions for ecological habitat restoration. The Park Service received several hundred million dollars for "infrastructure," with about half earmarked for natural infrastructure, as opposed to fixing up roads and visitor facilities. So how can EPA work more effectively with the other agencies that have been doing this kind of thing? Many more examples include the Forest Service, Soil Conservation Service, and others.

Looking at the list of people attending this conference, I find it surprising that attendees are mostly from EPA. I counted two people from the Soil Conservation Service (SCS), three from the Park Service, two from the Fish and Wildlife Service, and two from the Army Corps of Engineers. Why aren't more people from other agencies here? What does that tell us?

In Washington, people often say, "Ah, those EPA people, all they care about is toxic chemicals. They don't know anything about stream habitat in the physical sense or that sort of thing."

This is an example of the problem we work with—the enormous gulf between agencies. In the last couple of years, my little staff of a half-dozen people has worked with the Fish and Wildlife Service. We have experienced tremendous problems with the different cultures. They do not really understand what we do. Unfortunately, they think they do, which makes it even worse; and visa versa—we at EPA are just as guilty.

So I am interested in what people think about how we can work together more effectively. This is one microcosm. What if, collectively, EPA and other agencies receive a hundred million or more dollars from this economic package for ecological restoration. Are we all going to go off our own separate way and do our own thing with the money? Or are we going to try to get organized somehow and work together?

■ **Comment—Bill Kruczynski:** In working on the five-year-old Gulf of Mexico program, my experience in using other agencies' expertise has been to bring them along as full partners in developing "action plans" or "action agendas." The first thing is to prioritize the issues and the at-risk habitats. We have taken on our first project with sea grasses and emergent coastal wetlands. We are now identifying an interagency task force where everyone is a partner, and naming hot spots or pilot projects to put some things into the ground. The next step is a major large-scale restoration, with SCS providing the plant material, the Corp of Engineers providing some of the earth moving, Fish and Wildlife Service providing some of the monitoring—and EPA clapping, but being a full partner.

■ **Question:** You are predicting how, with new money from the Clinton package, the federal agencies will work together in the newer programs. You could also look back at how the Corp and the EPA have been working together and cooperating in the current 404 programs. Has that been to people's satisfaction?

■ **Answer—Bill Kruczynski:** Is the existing 404 program, administered by the Corp of Engineers, satisfactorily achieving restoration? Is that your question?

■ **Question:** No, are the two federal agencies working together in cooperation?

■ **Answer—Bill Kruczynski:** Not historically—we are at opposite ends of the spectrum. The memorandum of agreement between EPA and the Corp on mitigation was a major watershed in the greening of the Corp of Engineers. Since that event, at least in our region—we deal with eight versus nine Corp districts—all but two have come along. Our response has been to try to do the ecologically right thing.

■ **Comment—Milo Anderson:** Ditto for the National Environmental Policy Act (NEPA), which all agencies must comply with to manage their resources. For instance, every 10 years the Forest Service must do a forest fly plan that can be reviewed by every agency. EPA is required to look at all these plans. In our region at the annual environmental roundtable—not the last one, but the one before— an interagency agreement was signed to set the stage for interagency cooperation. We have 15 signatures from federal agencies, state agencies, and some conservation organizations. There are some successes, but I would like to hear any criticisms, too, including the NEPA action.

■ **Comment—Wayne Schmidt:** I have three points on the issue of coordination. The first one regards external EPA coordination. Someone in a state agency that deals with CERCLA (Superfund) cleanups and works with EPA made the comment that frequently the Superfund Branch has a cavalier approach and does not communicate with other branches because they are so driven to get a site off the list. They need to incorporate others' recommendations. If they did, they would be erring on the side of protectiveness. Legally, they have no basis to chose less expensive remedies if they are not protective. That is a common theme.

Second is the issue of integration or coordination with other agencies. A lot of talk today is about coordination with other agencies; while I do not see it, it may be there. How many are familiar with the Great Lakes Fish and Wildlife Restoration Act of 1990? I did not know it existed until recently either, but it is a valuable opportunity to promote cooperative partnerships and restore Great Lakes resources. Is there an opportunity for greater liaison with the Fish and Wildlife Service, once a coordinator for this program is hired by the Service?

Region V needs a renewed commitment to the national program under the Great Lakes Water Quality Act. The comments, philosophy, and the attitudes toward the International Joint Commission (IJC) is not particularly constructive. Whether or not you like the IJC, it provides opportunities and authorities for progress that we lack by working individually. The IJC policies for zero discharge, sunsetting of chlorine, and other issues are increasingly under attack. The last thing IJC needs right now is hostility from EPA. Sometimes it is embarrassing; certainly it is not constructive.

The opportunities are there. An appreciation for the role and the moral authority of the IJC and its efforts for ecosystem restoration in the Great Lakes needs to be recognized and supported.

■ **Question—William G. Painter:** While we hear about toxic chemicals, and I know they are important, we need to think about more than just toxic chemicals. Is that all you need to do here? Are all the streams in great physical condition? Do you have most of the wetlands you had before? EPA once again is focusing on human health because people are frightened about toxic chemicals. That is what people are most interested in, but that will not necessarily achieve ecological restoration. What is the answer to that?

■ **Answer:** From my perspective from a state agency in Minnesota, we have talked about the landscape scale affecting a given resource that we want to restore, in this case in the Great Lakes. We need to change what is going on in the landscape, which ultimately affects the quality and value of those Great Lakes. We are talking about landscape treatment or watershed treatment; but what is missing in this symposium's program is the incentive to effect land use changes by private land owners across the country.

Charlie Wooley pointed out the fair amount of interest and first-time knowledge that such a program existed for private land owners. I will be talking in a later panel about a program in the state of Minnesota. I look forward to questions about private incentives or incentives for private land owners.

This symposium needs to address what incentives are out there rather than just focusing on what regulations we can all use to achieve restoration. Restoration will be a small tool in the overall needs. Incentives, education, and information will be much more influential and substantial tools. Perhaps we should have a separate breakout session Thursday morning to just focus on incentives.

■ **Comment—Bill Kruczynski:** Earlier, your deputy administrator recognized that we are no longer in an era of expanding federal budgets and charged us with coming up with a new slogan to get more bang for the buck in restoration. Here is my attempt: "ecological restoration, global 'cents'ability." That gets across several points. One is that certainly restoration costs money; it could cost a lot of money. But what is good for the environment and ecological integrity is good for the economy. Putting fishable, swimmable streams back certainly makes economic sense and gets at the point of global stability. Our charge is to leave the world a little better for kids than we found it. That is why we are here.

I am really optimistic about our ability to replace ecosystems. It takes a long time. I know they are not fully successful until the eagles land, but a lot in the ground is 20 years old and showing progress. The goshawk nesting in a restored forest is a good example. And it makes sense.

In fact, we are really talking about three types of restorations. One type fixes something bad. Another type is part of a permitting program, like the 404 permitting program in which the National Wetlands Policy forum requires no net loss. To do that, we need to permit some things and mitigate for the losses in some compensatory way.

Restoration can also be on a global scale, a larger scale with no regulatory issue forcing it. We have inherited the environmental impacts of our ancestors, resulting in a degraded Great

Lakes system or a degraded Gulf of Mexico. We need to recognize that the ecosystems are not functioning optimally, find out what is limiting to the ecosystem, and restore it. For all three levels of restoration, you must assess and prioritize the problem, and go out and do it.

In a regulatory program, the goal should be to maintain credibility. If the Superfund makes decisions by itself, it will not maintain credibility because it is not doing the right thing and ignoring other issues. In order to maintain credibility, any regulatory program must be consistent; it must have rules and regulations—404b(1) guidelines, for example. It needs economy of scale and a touch of equity—that is, treating Republic Steel the same ways you treat Mom and Pop in settling an issue.

Finally, everything you do within a regulatory program must make ecological sense. The rules must be flexible enough to avoid a decision that does not make ecological sense. I have heard this 50 times out in the field: "Yes, we'd really like to accept your offer, but our rules don't allow it." Strictly interpreted, 404b(1) guidelines lead us to situations where a developer might propose something good for the system, but we cannot accept it because he has upland alternatives. But if he is destroying one-tenth of an acre, preserving 200 acres, and restoring a big system, our guidelines and our interpretation of the guidelines need to be flexible enough to allow that leeway and provide ways to accept offers that make ecological sense.

Our goal in a permit situation is to do what is ecological correct. Are we doing that now in the wetland program? The answer is no. We are issuing permits for wetlands destruction and requiring mitigation where warranted. We are doing this permit-by-permit and getting on-site and kind-for-kind restoration. Why? Because it is easiest.

Our justification is that we are replacing what has been lost in the watershed. But that is not what may be limiting to the watershed. We may have many cypress swamps in a particular watershed, and some other system may be limiting it. So we should design compensatory mitigation plans, not for expediency, but for ecological results. To do that, we must know what is limiting to the system. We must do the surveys and choose mitigation options to help maximize the ecosystems.

Tampa Bay lost 50 percent of its sea grasses; it has over 80 percent of its mangroves. If someone wants to destroy one-tenth of a mangrove acre, Tampa Bay's best interest may be in water quality or sea grass improvement instead of putting back an acre of mangroves when that is not limiting to its fisheries. Our current wetlands permitting system puts back all these little restoration sites in isolation, not linking them in a landscape context. Joy Zedler talks about "shake-and-bake" wetlands; I call them "postage stamp" wetlands. We do it because it is expedient.

How can we get better? How can we do things that make ecological sense? As mentioned before, we can develop watershed management plans, making all decisions based on what is limiting to a particular watershed. In Tampa Bay, for example, coastal emerging wetlands are limiting. So for any dredging project requiring mitigation, require coastal emerging wetlands or bird nesting habitats, if that is what is limiting. Or require upland spoil piles because tern nesting habitat is limiting to the full function.

In a recent study, we looked at restoration mitigation and permitting in the wetland program throughout all five Gulf states and asked the question: Is it working? The answer is no, because the projects are poorly designed and lack compliance monitoring. Normally, they are done by low bid. People walk away once they the projects are in the ground, and we do not see them again.

The current system is not working. We need to redesign the system. How can we use existing authorities to make it work more effectively? We need to share the load between all the agencies involved in permitting and compliance monitoring. We need to condition permits with standardized success criteria and monitoring requirements and have contingency plans in case the first choice of compensatory mitigation does not work. We need to work at the landscape level in watershed management plans to ensure that the restoration is meaningful.

How do you develop a meaningful restoration when no regulatory component is driving it? Tampa Bay, for example, does not have the speckled sea trout and red fish population it had in the '50s, because regional dredging has caused the sea grasses to decline. How do you develop a restoration plan that addresses that? What is the driving function? In the Gulf of Mexico program, we brought experts together from all the agencies, identified the resources in peril, and prioritized them. Without that, a political decision, not an ecological one, will be made.

Data is needed. Enough data out there show that the Great Lakes are loaded with a particular toxin that needs to be cleaned up quickly before anything else is done. We need to develop action plans or action agendas that lay out goals, objectives, and specific action items to address the relevant issues. The goal might be to achieve no net loss of wetlands in the Great Lakes. How can you get there? Achieving that goal is very subjective. You need a more effective regulatory program. You work with SCS in its programs; the action items fit into those objectives, and they are very specific. For example, convene a workshop annually on plant materials availability to guarantee enough plants to achieve these restorations.

Because of the fragmentation among the different agencies, ecological restoration needs some sort of federal oversight at the national level. The National Resource Center persuasively proposed national oversight in its book.

■ **Comment:** Some have proposed the President's Council on Environmental Quality be given a rebirth and place establishing restoration guidelines nationally on its agenda.

■ **Comment:** Regarding the national land use planning, if you look at the Great Lakes and other systems, more than half of certain toxins come in by air. So air issues clearly need to be addressed very strongly to get certain ecological restoration, particularly for great waterbodies.

■ **Comment:** In reality, if you were to take a recommendation from the National Academy of Sciences Report on restoring aquatic ecosystems, and restore 10 million acres at a cost of $10,000 per acre—a mid-range cost—that comes to $100 billion. I think that will take more than just encouraging land owners to do the right thing, or more than meeting with local governments and encouraging them to do the right thing.

The Fish and Wildlife Service's program with private land is a great thing and should continue. But restoration works with land owners by simply restoring the hydrologic regime to an area humans have altered, allowing those wetlands to come back quickly on their own. That is on the low end of the cost scale. We need to find ways to finance these things; they are not cheap, even using volunteers. And I do not know where we will get that kind of money; it will take massive amounts of money for a half-way decent job.

■ **Comment:** Of course, wetland restoration is not cheap. However, in the pilot program for the Wetland Reserve Program, the average cost per acre for restoring 49,000 acres—75 percent of the cost of restoration—was $52. This did not include the permanent easement purchase, but did include bringing back the hydrology and planting vegetation, if vegetation were possible.

■ **Comment—Wayne Schmidt:** There is no reason why we in the Great Lakes Basin cannot live in a garden with pieces of our native landscape all about us. Chris Gruendler was absolutely right—toxics are not everything. One of the fundamental laws of ecology is "save all the pieces." The work of groups like the Nature Conservancy to help us save those pieces absolutely complements our work on toxics. Poisoned food takes some of the fun out of living in a garden—that is where we are right now.

## APPENDIX: PRINCIPAL U.S. EPA LEGAL AUTHORITIES FOR ECOLOGICAL RESTORATION

**Clean Water Act (CWA): 33 U.S.C. § 1251 *et seq.*** The principal objective of the act is to **restore** and maintain the chemical, physical, and biological integrity of U.S waters. A chief subsidiary goal is to eliminate the discharge of pollutants into navigable waters. Permits are required for discharges into surface waters. Sections 1254 (f), 1258, 1268, and 1293a(h) address water quality in the Great Lakes. Sections 1267 (Chesapeake Bay), 1269 (Long Island Sound), and 1270 (Lake Champlain) deal with the water quality of other "great water bodies." Under section 1344 (section 404 of the CWA), the government can seek **restoration** of a wetland that has been filled without a permit or in violation of its permit.

The 1987 Amendments to Section 118 of the act (33 U.S.C. § 1268) formally created the Great Lakes National Program Office to research problems in the Great Lakes.

The Great Lakes Critical Program Act of 1990, which amended sections 1254(f), 1258 and 1268 of the United States Code (sections 104, 108, and 118 of the CWA, respectively) establishes deadlines for implementing remedial action plans (RAPs) and lakewide management plans (LAMPs) (first addressed under the Great Lakes Water Quality Agreement between the United States and Canada), and mandates the speedy implementation of uniform, stringent, and scientifically defensible water quality standards throughout the Great Lakes Basin. The requirements and timetables set forth in the Critical Programs Act further the goal of **restoring** and maintaining the chemical, physical, and biological integrity of the waters of the Great Lakes Basin. The requirements for the implementation of both LAMPs and RAPs specifically mandate the development of documents that "embod[y] a systematic and comprehensive ecosystem approach to **restoring** [emphasis added] and protection the beneficial uses of the . . ." waters of each of the Great Lakes and designated areas of concern within the Basin.

Section 1270 of the United States Code (section 120 of the CWA) also specifically requires the development of a pollution prevention, control, and restoration plan for Lake Champlain.

**Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): 42 U.S.C. §§ 9601 *et seq.*** CERCLA (also known as "Superfund"), as amended by the Superfund Amendments and Reauthorization Act of 1986, provides for the governmentally funded cleanup of primarily inactive, hazardous substances disposal sites. Based on strict liability, the government can recover its costs from current site owners, past owners and site operators, generators, and transporters of waste sent to the site. In addition to costs incurred by the government in conducting a removal or remedial action at the site, costs for restoration of damaged natural resources caused by releases of hazardous substances from the site can be recovered.

**Oil Pollution Act of 1990: 33 U.S.C. § 2701 *et seq.*** This act establishes liability for response costs in cleaning up a discharge of oil or hazardous substances into navigable waters or the adjoining shorelines and for damages resulting from the discharge. Under the act, the measure of natural resource damages is (1) the cost of restoring, rehabilitating, replacing, or acquiring the equivalent of the damaged natural resources; (2) the diminution in value of those natural resources pending restoration; plus (3) the reasonable cost of assessing those damages.

**Great Lakes Water Quality Agreement of 1978, as amended by Protocol signed November 18, 1987.** This agreement between the United States and Canada addresses the issue of Great Lakes water quality. Its purpose is to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes ecosystem. The agreement places great emphasis on the problem of toxic substances.

The agreement gives additional responsibilities to the International Joint Commission (established by the Boundary Waters Treaty of 1909). The agreement creates the Great Lakes Water Quality Board and the Great Lakes Science Advisory Board.

The 1987 protocol requires that RAPs be developed and implemented for all areas of concern and that LAMPs be developed for each Great Lake.

**Great Lakes Fish and Wildlife Restoration Act: 16 U.S.C. § 941 *et seq.*** This law requires a comprehensive study of the status, and the assessment, management, and restoration needs of the fishery resources of the Great Lakes Basin.

**State Statutes and the Common Law Public Trust Doctrine**

## STATUTES, INTERNATIONAL AGREEMENTS, AND PROGRAMS SPECIFICALLY PERTAINING TO RELEASES OF POLLUTANTS IN THE GREAT LAKES BASIN

### *Statutes*

**Clean Air Act (CAA): 42 U.S.C. § 7401 *et seq.*** The CAA was enacted in 1970 and amended in 1977 and 1990. It regulates emissions from mobile and stationary sources and commands that air standards be set by reference to public health. One section specifically addresses the issue of atmospheric deposition to the Great Lakes.

- **Section 7412(m): Atmospheric Deposition to Great Lakes and Coastal Waters.** This section calls for a study to identify, assess, and monitor the extent of atmospheric deposition of hazardous air pollutants to the Great Lakes and other coastal waters.

**Clean Water Act (CWA): 33 U.S.C. § 1251 *et seq.*** The goal of the CWA is to eliminate the discharge of pollutants into navigable waters. Permits are required for discharges into waters. Sections 1254 (f), 1258, and 1268 (also referred to as the Great Lakes Critical Programs Act of 1990) deal with water quality in the Great Lakes.

- **Section 1254 (f): Great Lakes Water Quality Research.** Calls for studies on the waters of the Great Lakes.

- **Section 1258: Pollution Control in the Great Lakes.** Permits projects to demonstrate new methods and techniques to eliminate or control pollution in the Great Lakes.

- **Section 1268: Great Lakes.** This section facilitates the achievement of the goals embodied in the Great Lakes Water Quality Agreement of 1978, as amended by the Water Quality Agreement of 1987 and any other agreements and amendments, by improving the organization and definition of EPA's mission, funding state grants for pollution control in the Great Lakes area, and improving accountability implementing such agreement.

- **Section 1268 et seq.: Great Lakes Critical Programs Act of 1990.** This act amends section 118 of the Clean Water Act. Its general purpose is to improve the effectiveness of EPA's existing programs in the Great Lakes by identifying key treaty agreements between the U.S. and Canada in the Great Lakes Water Quality Agreement (GLWQA), imposing statutory deadlines to implement these key activities, and increasing federal resources for program operation in the Great Lakes System.

  It requires EPA to publish proposed water quality guidance for the Great Lakes System that conforms with the objectives and provisions of the GLWQA and is no less restrictive than provisions of the CWA and national water quality criteria and guidance. The guidance must specify minimum requirements for Great Lakes waters in three areas: (1) water quality standards, (2) antidegradation policies, and (3) implementation procedures. The Great Lakes states must then adopt standards, policies, and procedures consistent with this guidance. If a state fails to do so, EPA is required to promulgate requirements for that state within a two-year period.

**Oil Pollution Act of 1990: 33 U.S.C. § 2701 to 2761.** The purpose of this act is to establish limitations on liability for damages resulting from oil pollution. Two sections of the act specifically address the Great Lakes.

- **Section 3002: United States–Canada Great Lakes Oil Spill Cooperation.** Pursuant to this section, the secretary of state is required to review existing agreements to determine whether additional agreements are necessary to (1) prevent spills in the Great Lakes and (2) ensure immediate removal.

- **Section 4108: Great Lakes Pilotage.** This section designates who may pilot a ship on the Great Lakes.

**Aquatic Nuisance Prevention and Control: 16 U.S.C. § 4701 to 4751.** The purpose of this act is to prevent, monitor, and control the unintentional introduction of nonindigenous species into U.S. waters. It was enacted primarily to address the problem of the zebra mussel in the Great Lakes.

## *International Agreements*

**Great Lakes Water Quality Agreement of 1978, as amended by Protocol signed November 18, 1987.** This agreement between the governments of Canada and the United States addresses the issue of Great Lakes water quality. Its purpose is to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Ecosystem, and it places great emphasis on the problem of toxic substances.

The GLWQA gives additional responsibilities to the International Joint Commission (established by the Boundary Waters Treaty of 1909). The agreement creates the Great Lakes Water Quality Board and the Great Lakes Science Advisory Board.

The 1987 agreement requires that RAPs be developed and implemented for all areas of concern and that LAMPs be developed for each lake.

- **Annex 15: Airborne Toxic Substances.** This section requires efforts to be made to research, monitor, and implement pollution control measures for controlling and reducing atmospheric deposition of toxic substances.

**Agreement between the Government of the United States and the Government of Canada on Air Quality, signed March 13, 1991.** This agreement addresses shared concerns regarding transboundary air pollution. It references the Great Lakes Water Quality Agreement and the Boundary Waters Treaty.

## *Memorandum Agreements*

**1986 Great Lakes Toxic Substances Control Agreement and the 1988 Memorandum of Understanding.** This agreement, signed by the eight governors of the Great Lakes states, is aimed at promoting greater regional cooperation and attaining elimination of releases of persistent toxic substances into the lakes.

In 1988, it was broadened to include Ontario and Quebec provinces and was signed in a Memorandum of Understanding (MOU). The MOU strengthened many of the original agreement's provisions and set timetables for achieving objectives.

The signatory states acknowledge that a large portion of pollutants entering the Great

Lakes system is from atmospheric deposition. Therefore, the states agree to consider the effects of airborne pollutants on the Great Lakes system when setting air emission standards and granting air emission permits.

**A Bi-National Program to Restore and Protect the Lake Superior Basin, September 1991.** This document identifies the responses of the federal governments of the United States and Canada; the states of Minnesota, Wisconsin, and Michigan; and the province of Ontario to the International Joint Commission's recommendation that "the Parties designate Lake Superior as a demonstration area where no point source discharge of any persistent toxic chemical will be permitted." (This recommendation was made in the Fifth Biennial Report on Great Lakes Water Quality.)

**U.S. Pollution Prevention Action Plan for the Great Lakes.** This 1991 agreement between the U.S. EPA and the Great Lakes states focuses on reducing toxic pollution and cross-media impacts of pollution. It also promotes pollution prevention practices throughout the Great Lakes Basin.

**Great Lakes Spill Protection Initiative.** This initiative is the result of a voluntary dialogue between the Great Lakes governors and the region's petroleum companies. Its goal is to ensure that the Great Lakes are well-protected against environmental damage from crude oil and petroleum product spills. ❑

# *PANEL: Policy and Management Approaches for Restoration*

PANEL: *Policy and Management Approaches for Restoration*

# *Ecological Economic Issues of Wetland Restoration*

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The University of Maryland International Institute for Ecological Economics (MIIEE) was established in 1991 to promote the growing transdisciplinary field of ecological economics. MIIEE deals with synthesizing ecological and economic systems to integrate training and research in science, economics, and public policy. Ecological restoration, a policy and management issue requiring integrated ecological economic analysis, is a significant part of my work. The growing controversy over wetlands restoration is a high stakes economic and ecological issue, with applied ecological economic research yielding results directly relevant to important policy decisions.

The wetlands restoration potential is intriguing. It offers the opportunity to improve and possibly expand our nation's deteriorated wetlands resource base. To date, however, most wetland restoration has been mitigation for lost natural wetlands and has failed to live up to expectations. Wetland restoration issues illustrate the following three critical conflicts and challenges facing ecological and economic researchers and those involved in formulating environmental policy:

- Aligning institutional perspectives to the scale of the resource problem,
- Accepting scientific uncertainty, rather than waiting to "prove" everything before we act, and
- Accepting that we cannot afford to measure the economic value of all environmental benefits.

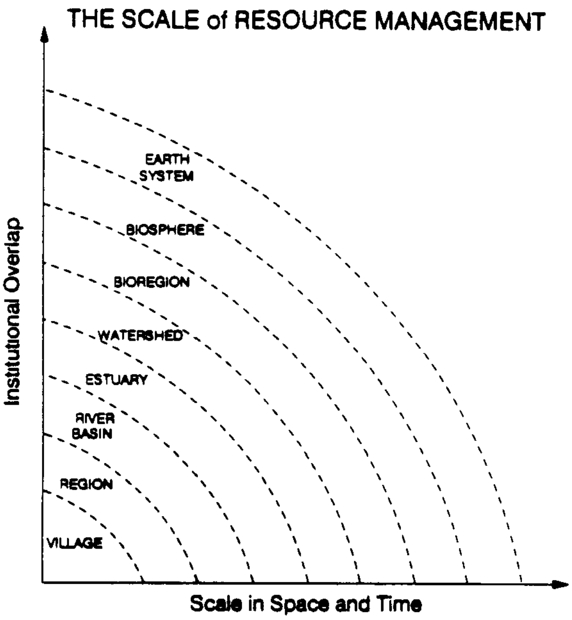
## Aligning Institutional Perspectives

For effective resource management, institutions must understand the scale of the resource problem and the potential stakeholders. The number and extent of institutional involvement is roughly proportional to the problem's scale and complexity. The more interrelationships between resource systems and linkages through space and time, the larger the number of institutions involved in management decisions. In wetlands restoration, for example, stakeholders include U.S. EPA, state and local environmental planning commissions, DOT, and DOE. In addition, municipal, commercial, residential, and industrial developers and organizations such as Ducks Unlimited are involved. Ecological economics is about synthesizing the ecological and economic interests—taking a broad perspective about the causes and consequences of resource problems.

Because of our historically narrow perception of resource problems, we have structured our existing institutions to deal only with fragments of ecological problems. Local, regional, and even national organizations and resource agencies deal with only part of each problem, resulting in disjointed environmental policies, especially affecting wetlands.

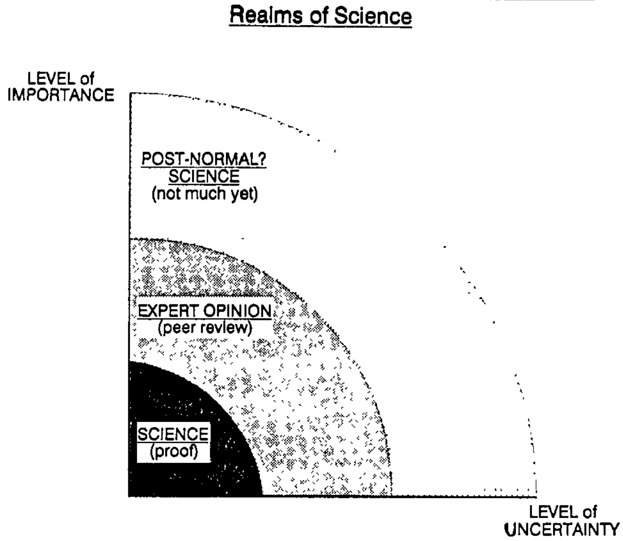
Complex modern resource problems require increasing the number and scale of institutions involved, thereby increasing institutional overlap (see Fig. 1). Wetland restoration issues, for example, should be treated at the watershed level as part of a hydrologic system, instead of as isolated resources. This requires new institutions, since watershed boundaries do not often

**Figure 1.—The scale of resource management.**




*adapted from Norton (1991)*

**Figure 2.—Realms of science.**




*adapted from Funtowicz and Ravetz (1991)*

fall neatly within single jurisdictions. To develop a rational wetlands policy, we must overcome significant institutional hurdles.

## Accepting Scientific Uncertainty

Our most important national and global natural resource problems have high levels of uncertainty that simply cannot be reduced in the time we have to manage them. Scientific research that accepts uncertainty as a given can, and in many cases should, take precedence over current research methods based on reducing uncertainty. Ozone depletion, wetland/watershed management, and deforestation are critical issues that require policy and management decision without extensive, statistical proof. Figure 2 illustrates a direct correlation between the *importance* of the scientific question and its level of *uncertainty*.

The scientific community prefers to comment on issues of pure science with low uncertainty (Figure 2, bottom right) based on controlled experiments, replication, and proof. The community's reluctance to address policy issues without hard scientific evidence can have tragic results because their input is more valuable in the face of uncertainty. The void is often filled by lawyers or policy wonks who serve special interests and use scientific uncertainty to their own advantage.

## A Lack of Economic Measurements

The economics profession has difficulty developing credible methods to measure the value of non-use benefits, life-support functions, keystone species, and the like. Some conventional economists believe only in traditional market value indicators and that all challenges and problems can be resolved by internalizing "externalities" in an otherwise well-functioning market system. Alternatively, we can assign safe minimum standards for natural resource protection based on measures of ecological importance and reversibility (King, 1992a).

Wetlands have many ecological and economic functions and values (Fig. 3), most of which are difficult to measure. Sediment trapping, for example, has a multitude of economic/ecological pathways to delineate, trace, and value to determine its overall economic value (Fig. 4). Sediment trapping reduces water turbidity, which enhances submerged aquatic vegetation, which serves as habitat for juvenile fin fish, which improves commercial and recreational catching, and therefore generates economic value. Sediment trapped by wetlands also reduces the need for dredging, allows for more cost effective hydropower, and so on. One could spend a lifetime and a fortune trying to justify the value of that one wetland function and still not be able to generate a legally defensible "proof" of loss. We will never be able to justify protecting wetlands, an important part of our ecological infrastructure, on economic grounds.

**Figure 3.—Wetland functions and values.**

| WETLAND FUNCTION | TYPES OF VALUE | WETLAND FUNCTION | TYPES OF VALUES |
|---|---|---|---|
| A Groundwater Recharge/Discharge | Maintain healthy drinking water | L Agriculture - low intensity grazing | High productivity, low farm costs |
| B Floodwater Storage Conveyance/ Desynchronization | Reduces soil erosion, property damage | M Energy (peat, etc ) | Major subsistence energy source with some commercial value |
| C Shoreline Anchoring | Protects beaches, property, ecosystem | N Natural Products-timber,hay,etc | Supply wholesale/retail markets |
| D Storm Wave/surge Protection | Reduces erosion, property damage | O Microclimate Regulation | General life support; ill-defined economic linkages |
| E Sediment Trapping | Maintains aquatic ecosystems; reduces dredging requirements; maintains hydropower | P Global Climate Regulation | General life support; ill defined economic linkages |
| F Pollution Assimilation | Reduces treatment costs, improves public health | Q Carbon Cycling | General life support; significant but unknown economic linkages |
| G Nutrient Retention/Cycling | Maintains nitrogen balance | R Storehouse of biodiversity | Direct, indirect and serendipity value of scientific, medical discoveries, genetic pools, seed banks |
| H Fishery Habitat | Better commercial/recreational fishing, lower seafood prices; improved international balance of trade | S Active Recreation | Boating, swimming, etc. |
| I Waterfowl Habitat | Better hunting, birdwatching, etc | T Passive Recreation | Sight-seeing, birdwatching, etc |
| J Habitat for Fur-bearers | Improved commercial and recreational opportunities | U Natural Laboratory/Classroom | In-field research/teaching - kindergarten through adult |
| K Food-chain Support | Off-site benefits to freshwater anadromous, marine fish, etc | V General Aesthetics | Open space, natural beauty, spiritual enrichment |

POTENTIAL VALUATION METHODS

| | | | |
|---|---|---|---|
| MA | Market Analysis | TC | Travel Cost |
| FI | Net Factor Income | CV | Contingent Valuation |
| SC | Substitute cost | HP | Hedonic Pricing |
| RC | Replacement Cost | PM | Participation Models |
| | | CA | Costs Avoided |

## Economics of Ecological Restoration: A Closer Look

In our four-year investigation into the economics of wetland restoration, we evaluated both cost and success, or performance data, and found both to be very low. Looking deeper at incentives in the wetland mitigation market, we concluded that costs and success rates were low because no one was buying high-quality wetland restoration. The wetland mitigation market provides for low-cost permits, not high-quality restoration.

From an economist's perspective, this represents a perverse market incentive. Buyers are normally price and quality conscious and only buy what works. A permit in the mitigation market, however, works just as well whether or not the restoration works. Quality control will not exist as long as regulators lack the skills and inclination to evaluate quality restoration work. Without government standards, we will continue to see low-quality, poor performance restoration work. Past restoration failures are not caused by scientific failure but by failure to impose mitigation quality standards. For market-related mitigation, the government must accept a permanent, full-time role in imposing quality. However, to develop and implement quality standards, we must assess our current knowledge about wetlands restoration and decide where we want to go with it.

## The Learning Curve

Our ability to restore ecological functions can be measured on a learning curve (Fig. 5) used in complex applications of science and technology (e.g., heart surgery, space exploration, microprocessing). Building on basic science and engineering (stage I) and some early experimentation (stage II), we make initial attempts to apply the new technology (stage III). After comparing the results of independent applications (stage IV), we see some standardization begin to emerge (stage V), reducing uncertainty about results and helping to isolate problem areas. At this stage, the new technique's potential becomes apparent. Practical applications do not emerge, however, until practitioners develop specialized equipment and materials (stage VI) that simplify the application and reduce costs. These promote the widespread and routine adoption of the tech-

**Figure 4.—Tracing economic impacts of wetland loss; pathway E—sediment trapping.**

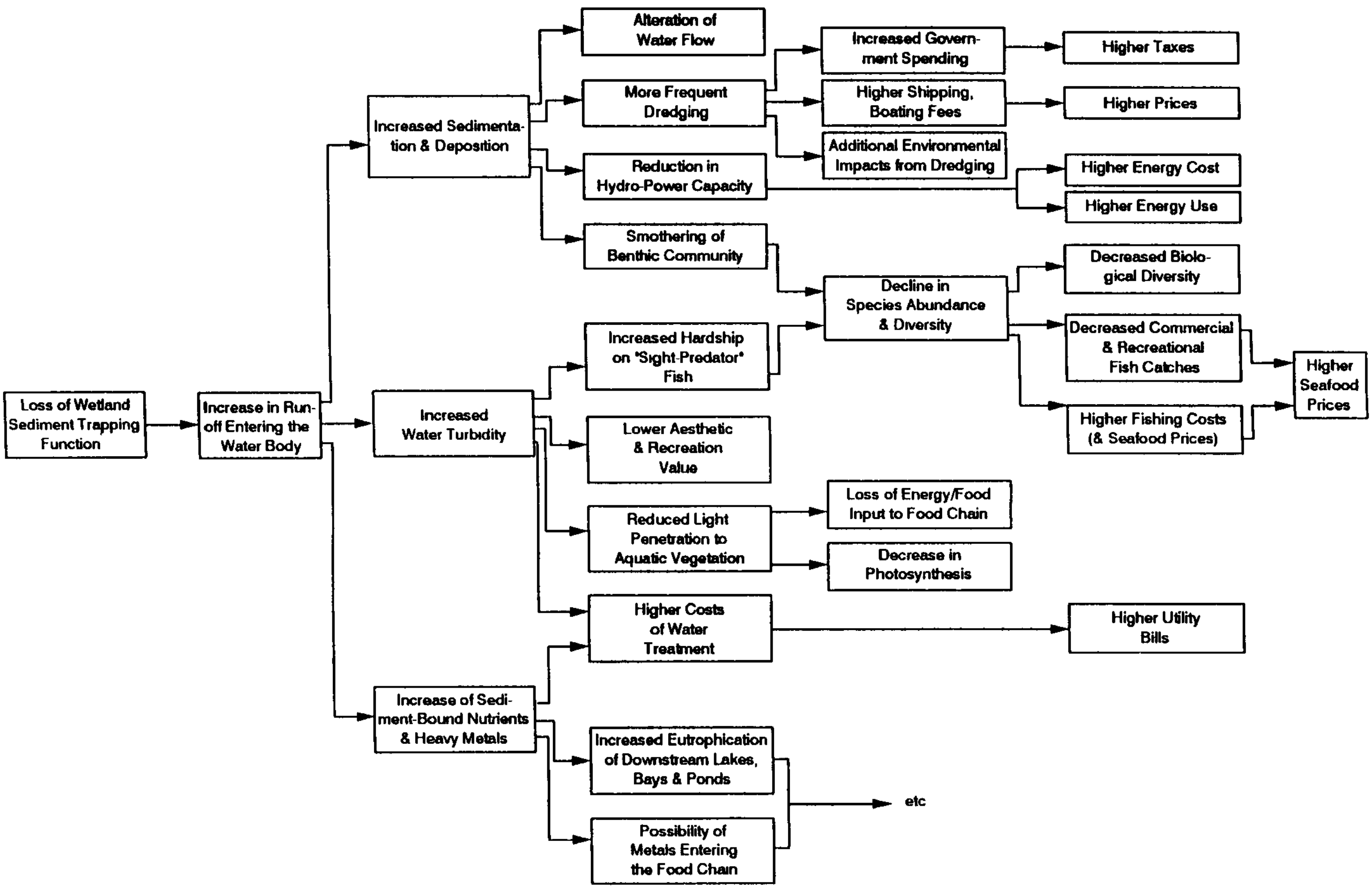
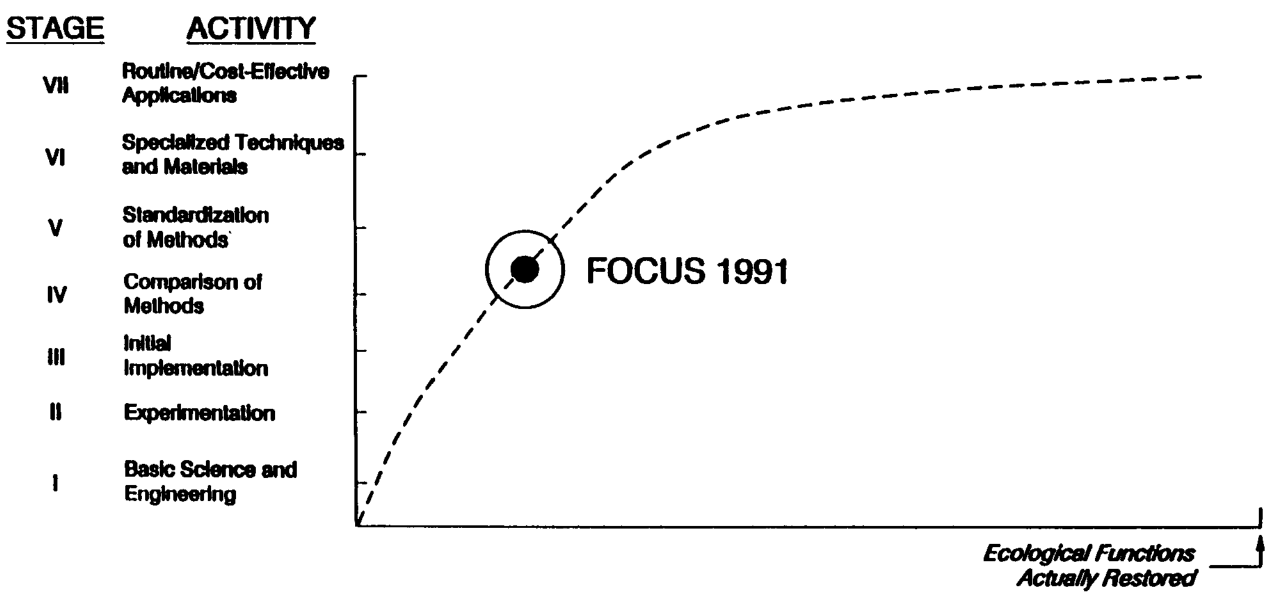



**Figure 5.—Where are we on the learning curve for ecological restoration?**



nique and, if the technique actually works, accelerates the rate of social payoff—in our case the ability to replace lost ecological functions.

Ecological restoration received a jump start on the learning curve. Restoration practitioners had been testing methods and materials and exchanging ideas for years before scientist and engineers gave much attention to restoration ecology. Even though scientists and engineers are still at developing our knowledge base, we are entering the critical stage (stage V) of emerging industry standards.

Basic research and experimentation are still underway. But we are systematically reviewing and camparing fragmented information about restoration successes and failures collected from scientists and practitioners worldwide (stage IV), particularly for wetlands and other aquatic systems—the focus of most recent mitigation efforts. Similar trends are evident from deserts, woodlands, bat caves, and other ecosystems with less obvious economic value.

Based on these reviews and over the objections of those who believe that too little is known or that ecological restoration is impossible, rough standards for restoration work will soon be appearing. The only questions remaining are what these standards will be and how they will be influenced by cost and quality considerations. And as techniques become standardized, standards will move towards greater and greater efficiency, and cost will decrease accordingly.

A learning curve normally has countervailing forces. One force pushes change and new technology; another force restricts it. Perverse incentives in the mitigation market create a unique situation in restoration. Normally, environmentalists and developers would be on opposite ends of a conflict. However, the environmental community has resisted any real restoration research, fearing the results will sidetrack the conservation agenda. Developers, while interested in restoration for mitigation, resist quality controls that will engender contempt for what has been passing as mitigation. So, both forces are restricting ecological restoration, causing years of delay in achieving restoration goals (King, 1991, and King, 1992b).

## Where We Want to Go

Since our initial query into restoration cost performance found a poor and invalid historical record, we pursued high-quality, first-hand information for a more accurate picture of wetlands restoration potential. After discovering that many wetland scientists (such as Mary Kentula's group at the EPA Environmental Laboratory in Corvallis, Oregon) have been investigating performance considerations, we began working with restoration experts to develop cost performance profiles and provide insight into current industry standards.

One research focus is determining the project's success level and recovery speed compared with the amount invested in the restoration effort by analyzing how variations of specific restoration tasks (and associated costs) affect the functional recovery level (see Fig. 6). A commonly cited example is opting to seed (or to just allow for natural revegetation/succession) over planting. Planting requires more intensive material and labor cost. However, if planting were successful, the quick structural and functional recovery could be well worth the added costs.

In the case of ecological restoration of mitigation, government decisions regarding such areas as sequencing and delineation determine all factors affecting the location and shape of the supply and demand curve (see Fig. 7).

The government must establish design, engineering, and performance standards before any rational industry will grow up around restoration. In mitigation banking, for example, the economic cost and risks are very low for banking credits sold at the project planning stage. However, if sale requires a fully functioning wetland, the economic costs and risks are enormous. If a wetlands mitigation market is to develop, we will need to strike a balance between the two.

## Wetland Mitigation Markets

Economic and ecological balance issues should be addressed when deciding overall watershed goals. Watershed plans should determine the trading rules under which everyone operates, drive the kind of trading allowed, and define the units and rules of exchange. Then economists can determine various exchange incentives. In a recent study (Shabman, King, and Scodari, 1993), we examined the feasibility and potential benefits of promoting wetlands mitigation trading through "entrepreneurial" banking. The study's finding and recommendations addressed six major themes:

1. **Advanced credit sales.** Regulators' concerns about using private credit markets to satisfy mitigation requirements center around the risk that created or restored wetlands will fail. Most mitigation banking guidelines say the banked wetlands used to satisfy mitigation requirements must be fully functioning or self sustaining. Transferring this "zero risked"

**Figure 6.—Creation and restoration tasks.**

*Phase I Preconstruction*

| Task | Description |
|---|---|
| 1.1 Background Research | Determine goals, constraints, performance criteria, budget, scheduling, etc. |
| 1.2 Identify Alternative Sites | Based on acceptable location, hydrology, soil, substrate, geology, etc. |
| 1.3 Develop Concept Plan | Obtain approval for general plan before final site selection and plan specification |
| 1.4 Select/Acquire Site | May include upland buffers and watershed area, and easements through adjacent property |
| 1.5 Develop Plans and Specifications | Final surveying, hydrological/geological profiles, engineering and construction drawings, planting and seeding specifications, etc. |
| 1.6 Select Contractors | Evaluate bids and award contracts |

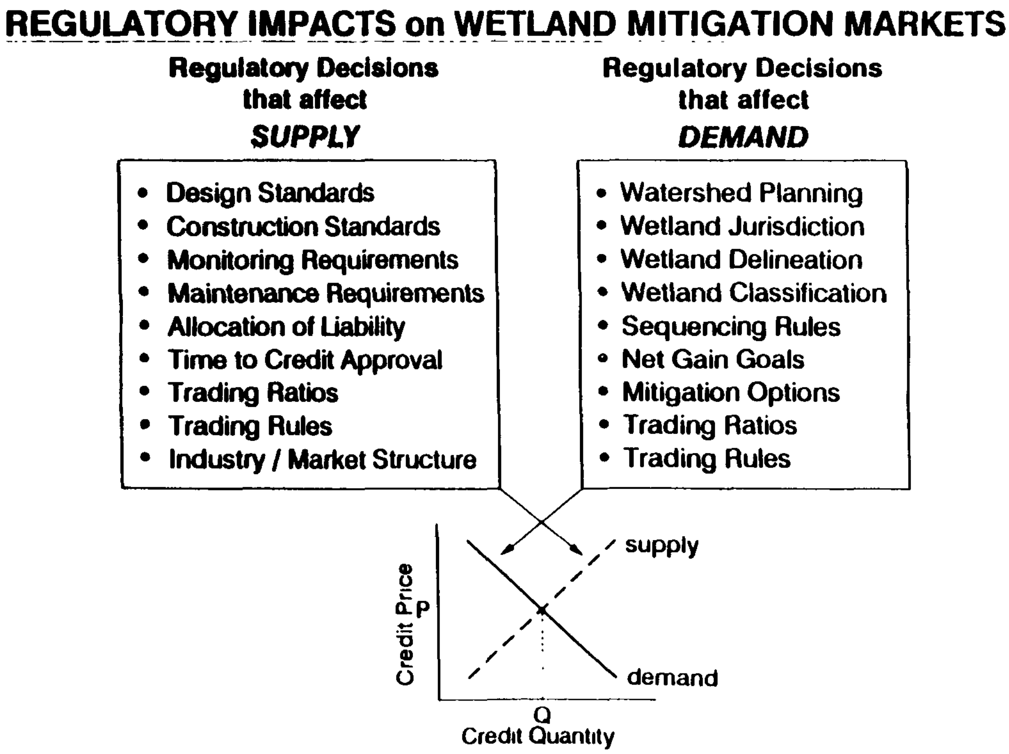
*Phase II Construction*

| Task | Description |
|---|---|
| 2.1 Site Preparation | Primarily earth moving (i.e., excavation and backfilling) |
| 2.2 Acquisition of Plant Materials | Plants and seeds from nature or wetland nurseries; may require precise timing |
| 2.2 Installation of Plant Materials | Hand or mechanical planting and seeding |
| 2.3 Fertilize and Water | Special requirements during initial establishment |

*Phase III Post-Construction*

| Task | Description |
|---|---|
| 3.1 Site Maintenance | Predator control, weeding, storm damage; especially during initial year or two |
| 3.2 Modifications | Adjust hydrology or plant mix to ensure natural sustainability |
| 3.3 Monitoring | Routine observations of wetland characteristics and functions for specified period |

**Figure 7.—Regulatory impacts on wetland mitigation markets.**




strategy to the credit market alternative would make credit suppliers bear all the risk costs of mitigation failure. These costs would probably be too high for most firms to earn a competitive return on investment.

2. **Contract conditions.** Regulators must clarify the conditions for credit trades in memoranda of agreement and regulatory permits. These "contracts" must define rules for allocating the costs of project failure arising from controllable and uncontrollable factors.

3. **Allocating liability.** Credit suppliers should be held liable only for costs of controllable failures resulting from inadequate (nonstate-of-the-art) restoration design, construction, and management practices. This will provide incentives for using best management practices without undermining the economic viability or credit markets.

4. **Mechanisms and methods for allocating liability.** Regulators could use a variety of mechanisms—higher trading ratios, performance bonds, leases with "collateral" banks, and insurance systems—to allocate the controllable risks of mitigation failure to credit suppliers and permit applicants. The level of risk costs established in any particular mitigation case must reflect realistic probabilities of failure and repair costs.

5. **Balance and public risks and return.** A trading system that allows for advanced credit sales carries the largely uncontrollable risks of mitigation failure from limitations in the state of wetlands restoration science and from unpredictable natural events. To make this risk acceptable, higher trading ratios should be implemented.

6. **Regulatory reforms.** Regulatory reforms that introduce greater flexibility into the permit process could improve the operation of mitigation credit markets and enhance the success of compensatory mitigation.

If carefully structured, private credit markets can expedite and add predictability to the permit review process and offer a competitive economic return on investment to mitigation supply firms. Most importantly, credit markets can address the chief ecological and institutional reasons for the widespread failure of project-specific mitigation efforts (Scodari, 1993).

We must make many more policy decisions before we can determine if wetland mitigation banking is viable from either an investor or an environmentalist's viewpoint. But one thing is for certain—resource, especially wetlands, restoration will require new and innovative policy and management strategies that employ an ecological economics approach. Stay tuned.

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PANEL: Policy and Management Approaches for Restoration

# On the Watershed Ecosystem Approach

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*All ethics so far involved rest upon a single premise, that the individual is a member of a community of interdependent parts. His instincts prompt him to compete for his place in the community, but his ethics prompt also to cooperate (perhaps in order that there may be a place to compete for). The land ethics simply enlarges the boundaries of the community to include soils, water, plants and animals or, collectively: the land.*

*Aldo Leopold*
*Land Ethic, 1949*

Watersheds and watershed ecosystems are land units with circulatory water systems that contain surface water, groundwater, precipitation, trees, streams, and cows. Often they are in more than one jurisdiction. This makes the jurisdictional problem an extremely difficult one, although some places have solved it. While some of our planning is based on the essential role groundwater plays in the watershed, we must think of surface water and groundwater together. Leopold talks about the watershed in the *Land Ethic*—not just erosion, not just toxins, but the interaction of all its parts. And the wise tinkerer does not throw away any of the parts.

Ecological integration over the watershed is essential; political and jurisdictional cooperation between agencies and local government is even more complex. In our work around Lake Calumet in Illinois, we found over 600 political units involved in some way.

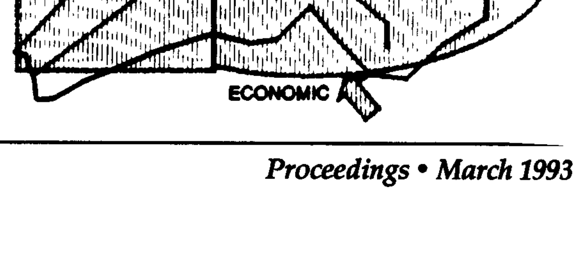
A watershed limits what you can do. Soil types are not uniform; soils vary over the watershed, which determines the watershed's capacity for public use.

## The Watershed Puzzle

The puzzle combines a scientific problem, in which scientists must show conclusively that activities in one part of the watershed affect people elsewhere, with the regulatory problem that protects the affected parties but does not restrict benign use (after you decide what benign use is). The joint solution for the scientific and regulatory problems must confront the question of equity among citizens within the watershed, because some portions of the watershed can support different economic uses.

A fundamental problem with this approach is that watershed economics and politics are not congruent. Sadly, jurisdictions compete for land and water uses that enhance the goals of that unit of government or jurisdiction. Often the goals of one unit will harm the potential future of a neighboring unit. Some discussion and compromise would improve the quality of life for both units in the long run. For most local governments, no forum for their compromises now exists (Fig. 1).

**Figure 1.—The noncongruency problem.**



Watershed study engenders several questions. What can the watershed do? How much can you modify those processes and maintain the long-term carrying capacity of that system? What are the conflicts? Every watershed has them. Can you make compromises through management? And do you have the human resources, the entities—public or private—to make these kinds of plans?

## Identify the Hydrology

The first thing to do in a watershed study is identify the hydrology—where the water comes from and where it goes. It is as simple and as hard as that. The second thing to do is nail down the land use. What are people doing out there? And third, study the processes that operate to cause change. Then, figure out the direction of that change. No ecosystem, no watershed stands still. The process of establishing goals, creating realistic compromise, and implementing plans takes time. Watershed planners must understand the direction and rate of change sufficiently well so as to intercept the ongoing changes. The situation changes as we plan and study. Thus, we must predict the conditions and momentum that will be operating when we actually begin implementation.

To understand the future, we need to look at the watershed's history. We collect ecological history. We tape record the people who have the information. We read old newspapers and journals. We learn from past mistakes. Remember, those who do not study history are forced to suffer it over again.

On the Pere Marquette watershed in Michigan, we did several things. We integrated a scientific model for flow, precipitation, surface water, and groundwater, and a conjunctive model for surface water and groundwater. We tried to integrate wetland streams and ponds. The aquatic restoration panel taught us that lake restoration success often means the destruction of a wetland or river. Mitigation successes may cause adverse impacts on a lake. Everyone thinks of success relative to their own pet ecosystem.

On the Pere Marquette, we looked at everything—water quality, fishery, bottom land vegetation, citizen data—anything we could get our hands on. We looked at history, geological studies, presettlement studies, after settlement studies. You can find this information on every watershed in the country. If someone were to try to figure out what happened on one of the Grand Calumet watersheds, they would find a lot. You could study a whole variety of ecological topics—heterogeneity, biodiversity, space, and so on.

## Plan for the Worst

Our lack of understanding about the self-regulatory properties of complex natural ecosystems frustrates our attempts to manage watersheds. We have confused the mechanical and stochastic properties of physical systems with the adaptive, often counter-intuitive homeostatic processes of biotic systems. Many watershed/wetland systems require spatial and temporal variability of external stimuli to support the diversity of organisms that allow the system to adapt. They thrive on risk and uncertainty.

We have attempted to manage this disconcerting inconsistency out of the system. In the process of making watersheds predictable and consistent, we have lost the biotic parts. Non-living systems just do not adapt well.

**We should manage our ecosystems so that they will persist during the probable worst case.** Most managers fail to study the formative history of their piece of landscape. They manage for a consistent maximum short-term yield of one product, such as irrigation water, wood ducks, navigation, or electric power. Their history is too short to see the important events that shaped the ecosystem they manage. This failure overlooks the importance of the mechanisms of change in watershed/wetland systems. Thus, often managers attempt to stop change and hold the system in a static, stagnant state.

## Plan in a Landscape Context

In watershed ecosystems, restoration plans should be developed in a landscape context. If not, the odds of failure are much higher. Collect the available data. A lot of good data is out there; it just may not be coordinated. Do not get too hung up in developing your geographic information system (GIS)—you can do a lot with overlays. A GIS, particularly one not up and operating, is like a sailboat or sports car—a hole into which you throw money. It can be valuable and fun if it is up and running, but do not become a slave to it.

To solve the agency and jurisdictional turf battles, focus on the resource. Use local citizens' groups and governments as sources. Work bottom up, not top down. Plan for the worst and you will not be disappointed. ❑

PANEL: *Policy and Management Approaches for Restoration*

# *Wetland Restoration in the Section 404 Program*

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The Corps of Engineers (Corps) section 404 regulatory program has evolved into one of the major factors leading to the restoration and creation of wetlands. Under that program, wetland restoration and creation, as well as enhancement and preservation, can be required as "compensatory mitigation" to offset unavoidable adverse impacts that result from permits issued for filling wetlands (see Table 1 for definitions).

**Table 1.—Definitions for Compensatory Mitigation.**[1]

| |
|---|
| **Restoration:** *Reestablishment* of the wetland conditions that historically existed at a site that currently provides reduced or no wetland functions and values. Restoration can range from partially to fully reestablishing the site's original wetland conditions. |
| **Creation:** Construction of a wetland at a site that was not wetland in the recent past (last 200 years). |
| **Enhancement:** Management techniques that increase one or more functions of an existing wetland *without changing wetland type* (e.g., prescribed burns to maintain a wet prairie). |
| **Exchange:** *Conversion* of one wetland type to another (e.g., flooding a sedge meadow to create a deep marsh for waterfowl habitat). |
| **Preservation:** Set-aside of wetlands in their existing condition. |

[1]Definitions generally follow those given in the paper "Options to be Considered in Preparation and Evaluation of Mitigation Plans," by William Kruczynski in the U.S. Environmental Protection Agency publication entitled, *Wetland Creation and Restoration: The Status of the Science. Volume II.* (1989).

I use the term "evolved" because compensatory mitigation has played an increasingly prominent role in the section 404 program. Today, many applicants have at least a conceptual compensatory mitigation plan when they submit a permit application to the Corps.

## Beginning to Understand

We are just beginning to understand how to successfully restore and create most types of wetlands. The question I am often asked is this: Given this situation, how can the Corps be issuing permits on the condition that wetlands be restored or created as mitigation?

Wetland regulations are perhaps 20 years ahead of the science. While the regulations allow for compensatory mitigation, we lack the scientific basis for determining with a high degree of certainty what methods work. That leaves the Corps in a difficult position. Frequently, the Corps cannot positively confirm that the proposed compensatory mitigation will be successful, nor can we conclusively show that it is destined for failure. This uncertainty has led some to suggest that the Corps deny all permits rather than rely on efforts to restore and create wetlands as compensatory mitigation. However, this is not a workable solution. Denial of a permit application is viewed as a very serious matter by Corps district engineers. To take that action, the Corps needs a definitive basis to show that the project is contrary to the public interest. Additionally, permit denials on a large scale would likely prompt adverse congressional action concerning the section 404 program.

In many cases, the Corps' approach has been to give the benefit of the doubt to the applicant and issue permits on the condition that wetland restoration and/or creation be accomplished as compensatory mitigation. Some of these mitigation plans are, in effect, experiments in wetland restoration and creation. Considering the scope of the section 404 program, these attempts at wetland restoration and creation are being conducted nationwide, involving thousands of acres and hundreds of thousands of dollars.

## An Ecological Learning Curve

The result is a learning curve in ecological restoration. We are now starting to see the results of these "experiments" and are learning from them. Looking back at permits issued just five years ago, I noted that what was accepted then as conditions for compensatory mitigation would not be accepted today. We have made a quantum leap in improving special conditions, techniques and monitoring, but we still have a long way to go.

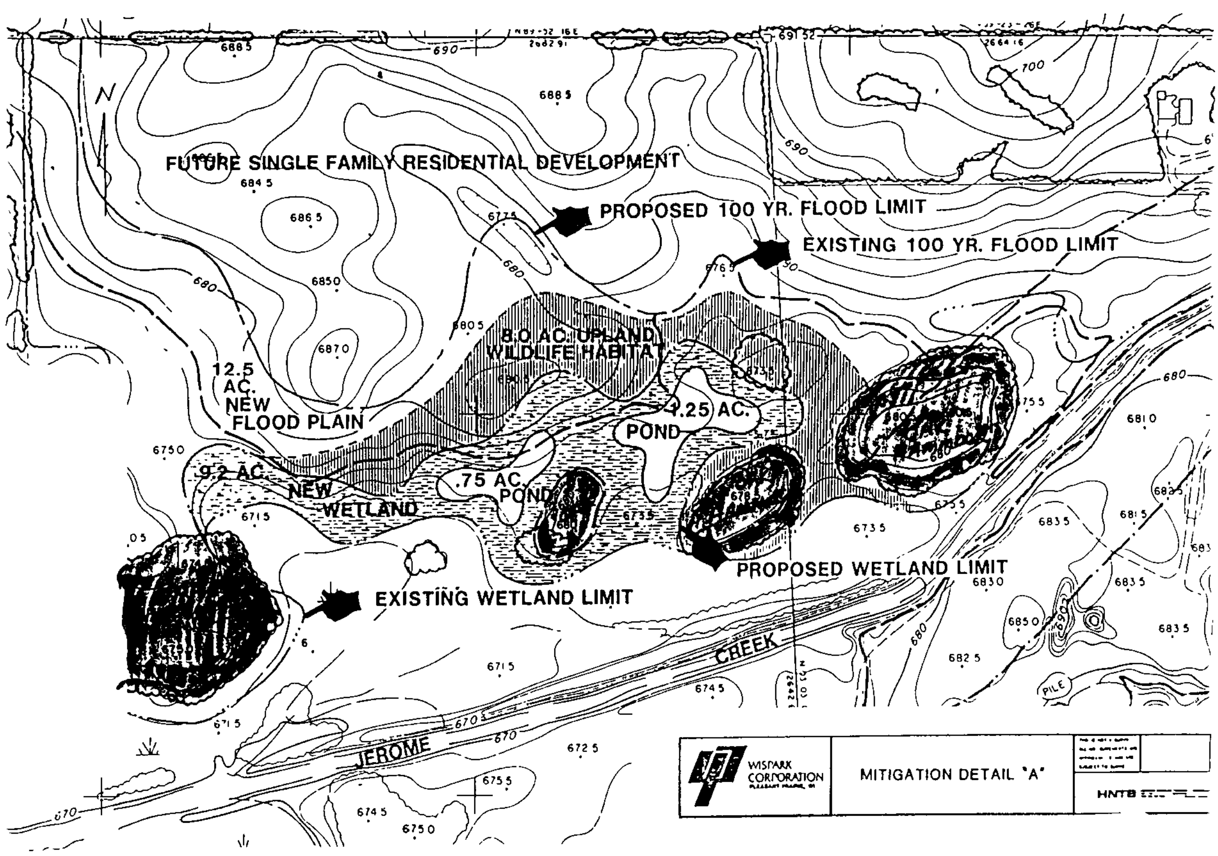
One of the most difficult questions is how do we define "success?" Does successful wetland restoration mean standing water, cattails, and a pair of mallards?

## The Wispark Case Study

The Wispark case study involves both wetland creation and restoration at a site adjacent to the Des Plaines River in southeastern Wisconsin. A section 404 permit was issued for construction of a new highway crossing the river and wetlands. Conditions on the permit required that compensatory mitigation be accomplished on-site at two locations: one in an agricultural field adjacent to Jerome Creek, and another immediately south of the new highway in an area that had been severely degraded by a gravel pit operation. As we shall see, these two locations illustrate the full range of what can go wrong and what can go right in our attempts at restoring and creating wetlands.

At the Jerome Creek site (Fig. 1), excavation created approximately nine acres of wetlands by lowering the agricultural field elevation to approximate that of the adjacent natural wetland—a sedge meadow grading to shallow and deep marsh. Also included was an 8-acre upland buffer planted with native prairie species. The intent was not to alter any existing wetlands, but rather to create an extension of the existing wetland complex that formed a corridor along the Des Plaines River.

**Figure 1.—Wispark - Jerome Creek Mitigation Site.**



During the first two growing seasons, this 9-acre area was rapidly colonized by a diverse assemblage of native emergent aquatics such as river bulrush, softstem bulrush, cattail and water plantain, none of which was planted. The species diversity was similar to that in the adjacent natural wetland complex; thus, the goal of creating an extension to the complex appeared to be realized. Wildlife use also paralleled that in the natural wetlands: Canada geese, blue-winged teal, sandhill cranes, Virginia rails, leopard frogs, northern pike fingerlings, and other species were observed in the created wetlands.

After four growing seasons, the 8-acre native prairie planting had become relatively well established. Problems included quack grass, but management should diminish these problems over time.

Compensatory mitigation can include management techniques to enhance existing wetlands. One of the best management options is prescribed burns. Burns are an important component of the Wispark mitigation plan, considering that the presettlement vegetation was primarily composed of oak savanna and wet-to-mesic prairie, all of which are fire dependent. Unfortunately, the general public equates fire with death and destruction. We need to educate the public to fire's beneficial use in managing natural areas. For example, a prescribed burn of a reed canary grass monotype at the Wispark site resulted in a pleasant surprise: the appearance of eastern prairie fringed orchids, a federally listed threatened species.

In contrast to how well things went at the Jerome Creek site, Murphy's Law applied to the attempted wetland restoration south of the new highway. The intent was to excavate fill placed in wetlands years ago by the gravel pit operation and construct a series of four shallow wildlife ponds. Shortly after the ponds were excavated, a compliance inspection found that the largest pond (4 acres) looked more like a bomb crater than a wetland mitigation site. Whereas flat slopes of 8H:1V were specified in the permit, slopes were actually much steeper. The permittee subsequently regraded the slopes.

A serious problem was that the excavations never exposed the native hydric soils thought to be underneath the fill. Instead, a claylike subsoil was exposed. In hindsight, we see two mistakes: (1) inadequate soil borings to determine the location and depth to the native hydric soils; and (2) no contingency plan, as a condition of the permit, required topdressing if the excavation did not expose a suitable substrate for the desired wetland vegetation. Mineral topsoil or organic soils could have been brought in for topdressing, but this was not a special permit condition.

What else could go wrong? One of the worst droughts in 50 years coincided with this work. Repeated seedings of the slopes and areas bordering the excavated ponds failed, leading to severe erosion. After four growing seasons (1992) and an end to the drought, these areas supported 50 to 60 percent vegetative cover. All four ponds retained water even during the drought. In fact, they are composed of deep, open water as opposed to shallow wildlife ponds.

## The Patrick Lake Mitigation Bank Case Study

Another example of an attempt to restore wetlands is the Patrick Lake mitigation bank of the Wisconsin Department of Transportation (WDOT). Patrick Lake is located in southern Wisconsin near Madison and is approximately 160 to 170 acres in size. Aerial photography dating to the 1930s shows a dynamic system, varying from open water to hemi-marsh to closed marsh. The basin, drained in the 1960s, was put into row crop production. Restoration of Patrick Lake was identified as a potential compensatory mitigation measure during review of a section 404 application for upgrading a highway segment located next to the basin. Dismantling the drainage system would restore the entire 160 to 170 acres of the basin, far in excess of the compensatory mitigation needed for this one project. Thus, WDOT coordinated with the other agencies and set up a mitigation bank.

As it turned out, dismantling the drainage system was the easy part. WDOT went through an arduous two-year process to negotiate purchase of the lakebed from several landowners. But WDOT was successful, and in the spring of 1992, Patrick Lake filled with water for the first time in many years. The immediate response from the seedbank resulted in tremendous vegetative growth that first year. Water plantain, broad-leaved arrowhead, river bulrush, softstem bulrush, and acres of smartweeds appeared among the previous year's corn stubble.

With the return of standing water and wetland vegetation, ducks, geese, swans, and shorebirds returned the first year of restoration.

In summary, Patrick Lake was an example of compensatory mitigation with a known high probability of success: restoration by reflooding hydric soils. ❑

## PANEL: *Policy and Management Approaches for Restoration*

# *Water Quality Regulations and Approaches to Support Ecological Preservation/Restoration*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This manuscript was submitted for publication in the proceedings after the Symposium on Ecological Restoration.

*The objective of this Act is to restore and maintain chemical,* physical, *and biological integrity of the Nation's waters.*

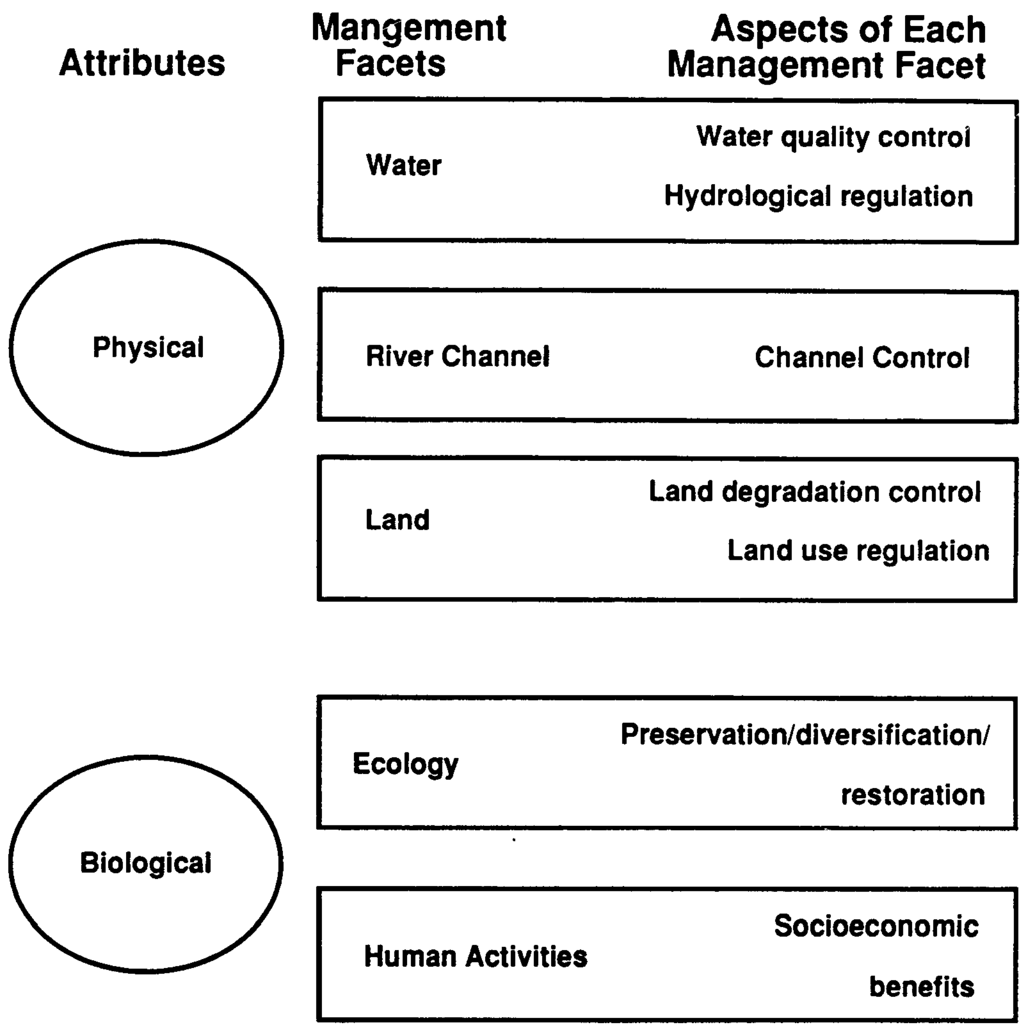
*Clean Water Act*
*Section 101(a)*

This paper responds to the need to clarify the objectives and rationale for habitat preservation/mitigation of aquatic systems to address water quality problems as an integral component to fully implement the Clean Water Act (CWA). Alternative strategies being developed as part of EPA's Office of Water Watershed Protection Approach should receive broader recognition and acceptance as a viable means to implement a more comprehensive (i.e., inclusive of ecological restoration) water quality program. Most water quality professionals understand that the second element (*physical*) of the opening phrase above from the CWA has not been well served by the programs developed to implement the Act. Further progress in restoring and maintaining the other two elements (chemical and biological) will be difficult without incorporating more explicitly preservation and restoration of physical habitat into the water quality program's mission. This can be accomplished to some extent by expanding the definition of water quality used by many water quality agencies to include the biological and physical properties of waterbodies (including the continuum of linkages with terrestrial systems). The focus would then be on "waterbody integrity." This paper reports on innovative waterbody strategies that result from an aggressive interpretation of the CWA and alliance with other resource agencies to create basin approaches that employ a more holistic management approach to waterbody problems. These strategies would be enhanced if the CWA is amended to broaden its mandate, giving waterbody integrity programs more explicit sanction to consider the physical and biological components (Figure 1).

## Background

Implementation of the CWA of 1971 and its amendments has resulted in significant improvements to the water quality of many U.S. lakes and streams. Many waters now support much more diverse and productive aquatic communities than prior to the Act. Initially, most of these improvements resulted from implementation of technology-based effluent limitations that brought about significant reductions in discharges of conventional types of pollution, such as municipal wastes with high levels of biological oxygen demand (BOD), gross industrial pollution, and others. The second round of water quality improvements has included water quality-based controls on toxic chemicals and whole effluent toxicity. These controls have brought additional improvements to the aquatic communi-

**Figure 1.—Facets of river basin management that should be incorporated in basin planning to address physical and biological attributes of river basins.**




Adapted from Downs et al. 1991

ties in many surface waters. Presently, the focus is on even more stringent chemical and toxicological limitations for point sources and controls of nonpoint sources. The costs of implementing these more stringent water quality standards are increasing rapidly, while the incremental improvements in aquatic communities likely to be gained are decreasing, and improvements are difficult to quantify. In some previously degraded surface waters, water quality has improved to the point where factors other than water quality limit or totally prevent full restoration of the aquatic community. These other factors include physical and biological habitat and water quantity.

A large proportion of U.S. surface waters, especially lakes and streams, have suffered from chemical, biological, and physical habitat degradation as a result of urbanization, deforestation, over-grazing, industrialization, agricultural practices, mining, flood control projects, channelization, reservoir and dam construction, diversions, dredging, and others. Because of improvements in water quality from control of point source discharges, restoration of the biological and physical habitat in these waters could produce large improvements in the structure and function of biological communities beyond those gained by improving water quality alone. Improvements in the physical and biological habitats of surface waters also can lead to improvements in water quality by increasing the capacity of aquatic ecosystems to process contaminants (i.e., restore assimilative capacity).

In its recently-issued report, the National Research Council (NRC, 1992) concluded that habitat degradation is a primary factor limiting attainment of beneficial uses of the nation's surface waters. The NRC also concluded that an accelerated effort toward restoration of aquatic ecosystems is needed, and that failure to restore aquatic ecosystems promptly will result in sharply increased environmental costs later, in the extinction of species or ecosystem types, and in permanent ecological damage.

The CWA is likely to be re-authorized in the near future. In the past, the cost effectiveness of new water quality regulations were generally not considered. The revised CWA, however, may likely require such economic considerations. Therefore, an evaluation of the cost effectiveness of alternative means of attaining beneficial uses of surface waters is needed. In addition, stream restoration projects often are labor intensive; therefore, use of funds for such projects has the additional benefit of creating numerous jobs, potentially in urban and rural areas with high unemployment rates.

This paper will provide a summary of policy and program approaches that support physical habitat preservation and restoration and provides a technical basis for the linkage of in stream restoration with traditional water quality programs by describing specific relationships between physical habitat factors and water quality parameters. The paper also reports the results of both a regional and site-specific scoping exercise to identify candidate systems for which physical habitat restoration should be a primary consideration. The paper describes a current project located on the South Platte River as a physical habitat restoration case study. This section also includes a preliminary economic analysis on a site-specific scale to evaluate by comparison the costs of a site-specific physical habitat restoration approach with a traditional treatment engineering approach. The final section reviews key issues that remain as obstacles to inclusion of physical habitat considerations into water quality programs.

## Summary of Program Approaches and Policy Options to Promote Habitat Preservation/Mitigation

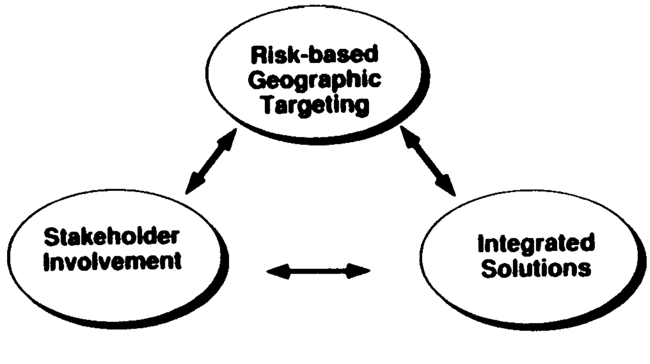
### *Basin Approaches to Water Quality Management (Watershed Protection Approach)*

Water quality programs have been created to reflect the structure of the enabling legislation (i.e., CWA). This structure provides a strong legislative mandate that has enabled water quality programs to establish their regulatory authority and has built a record of legal precedence in the courts supporting that authority. Water quality programs developed in this manner, however, have historically not been well coordinated or integrated. Water quality management strategies often reflect program requirements that may not be fully consistent with the issues most responsible for impairment to the waterbody. To achieve the objective of healthy aquatic ecosystems, water quality programs must have a framework that provides flexibility to form synthesis solutions that address problems with any or all of the elements (chemical, physical, biological) of the waterbody.

The Office of Water is supporting states that have requested assistance (North Carolina, Delaware, and Washington) to develop and implement basinwide water quality management approaches. This support is provided as part of the Office of Watersheds, Oceans, and Wetlands' Watershed Protection Approach. These are state-based initiatives, where the states are designing their own basinwide water quality management programs. These comprehensive geographically targeted risk-based water quality programs are designed to facilitate integrated solutions inclusive of physical habitat preservation/restoration. This approach is a synthesis of traditional regulatory programs, nonpoint source programs, and basin planning to achieve a broadly based stewardship of aquatic resources. In addition, the Delaware and Washington basin strategies are likely to include local planning groups and other State and Federal resource agencies. In these States, the definition of water quality has been expanded to be more inclusive of physical and biological components.

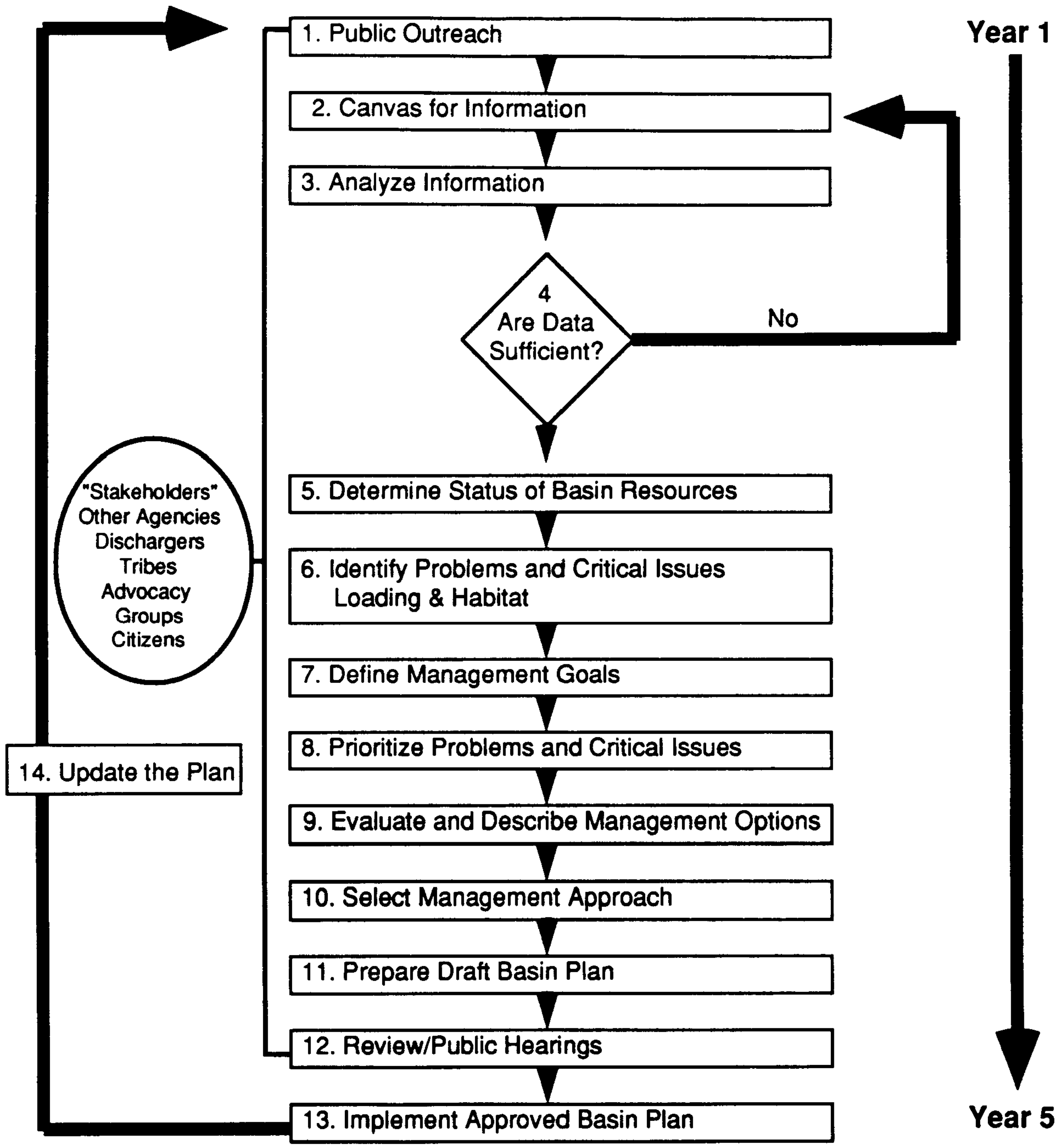
Figure 2 illustrates three principles featured in the basinwide approach: (1) risk-based geographic targeting, (2) stakeholder involvement, and (3) integrated solutions (U.S. Environ. Prot. Agency, 1991a).

**Figure 2.—Basin-wide planning elements.**



*Risk-based geographic targeting:* As illustrated in Figure 3, generic steps used to develop a basin plans, a unique feature of this approach is the collection of environmental data to determine priority waterbody issues within the basin. The use of environmental data to target specific water quality impairment is the "risk-based" component of the program. The steps listed in Figure 3 represent the framework that enables a risk-based approach to be taken by placing the monitoring and assessment components at the beginning of the waterbody management process. Therefore, use impairment, impacts on biological integrity, and violations of water quality standards are used to set the management agenda. Those stressors having the largest impact on water quality or posing the greatest risk to the integrity of the resource receive the most attention in the development of management strategies.

**Figure 3.—Major steps and information transfers in developing basin water quality management plans.**



"Risk" in the context of basinwide planning has thus far not meant probabilities of adverse effects, as is the case for ecological risk assessment (U.S. Environ. Prot. Agency, 1991b). Rather, it has been used as a more qualitative indication of impairment to human health and ecological resources, designated uses of the waterbodies, or a combination of these resulting from human-made pollution and natural processes, based on a review of environmental data. Phillips (1989) presents a probabilistic approach to targeting nonpoint source pollution control in a watershed context that could be used as a tool in the basinwide approach to make the risk analysis more rigorous and quantitative.

The program is based on "watershed units" (basins) defined by the States that are then set on an iterative five-year management cycle. The fundamental organizational unit of this approach—basin planning teams—target specific stressors based on their potential to produce impairment to human health, ecological resources, or designated uses. Basin planning teams must consider a wide range of potential stressors in watersheds (Table 1). The basinwide planning approach identifies the highest risk stressors within watersheds using water quality data, biological monitoring data, habitat suitability data, land use information, and information on the location of critical resources. All available funding sources are used to address the problems identified by the team regardless of whether the problem is a National Pollutant Discharge Elimination System (NPDES) permit, an urban nonpoint source management plan, or a habitat restoration project. Everything is on the table for the ranking and management strategy process.

The assessment tools include water quality models, statistical indicator indices, and geographic information system (GIS) overlays. The stressors with the greatest potential to yield impairments are targeted, and optimal corrective management strategies are developed and implemented. The targeting process may range from qualitative ranking to computerized techniques that incorporate various numeric criteria and weighing factors (Adler and Smolen, 1989). Figure 4 represents an idealized scenario depicting the relationship of various funding sources to the basin planning teams' ranking of priority issues. Due to resource limitations, not all issues identified are funded for corrective action in the

**Table 1.—Problems that may pose health or ecological risk in a watershed.**

- Industrial wastewater dischargers
- Habitat alteration, including wetlands loss
- Flow variations
- Municipal wastewater, stormwater, or combined sewer overflows
- Nonpoint source runoff or seepage
- Waste dumping and injection
- Accidental toxics materials release
- Atmospheric deposition

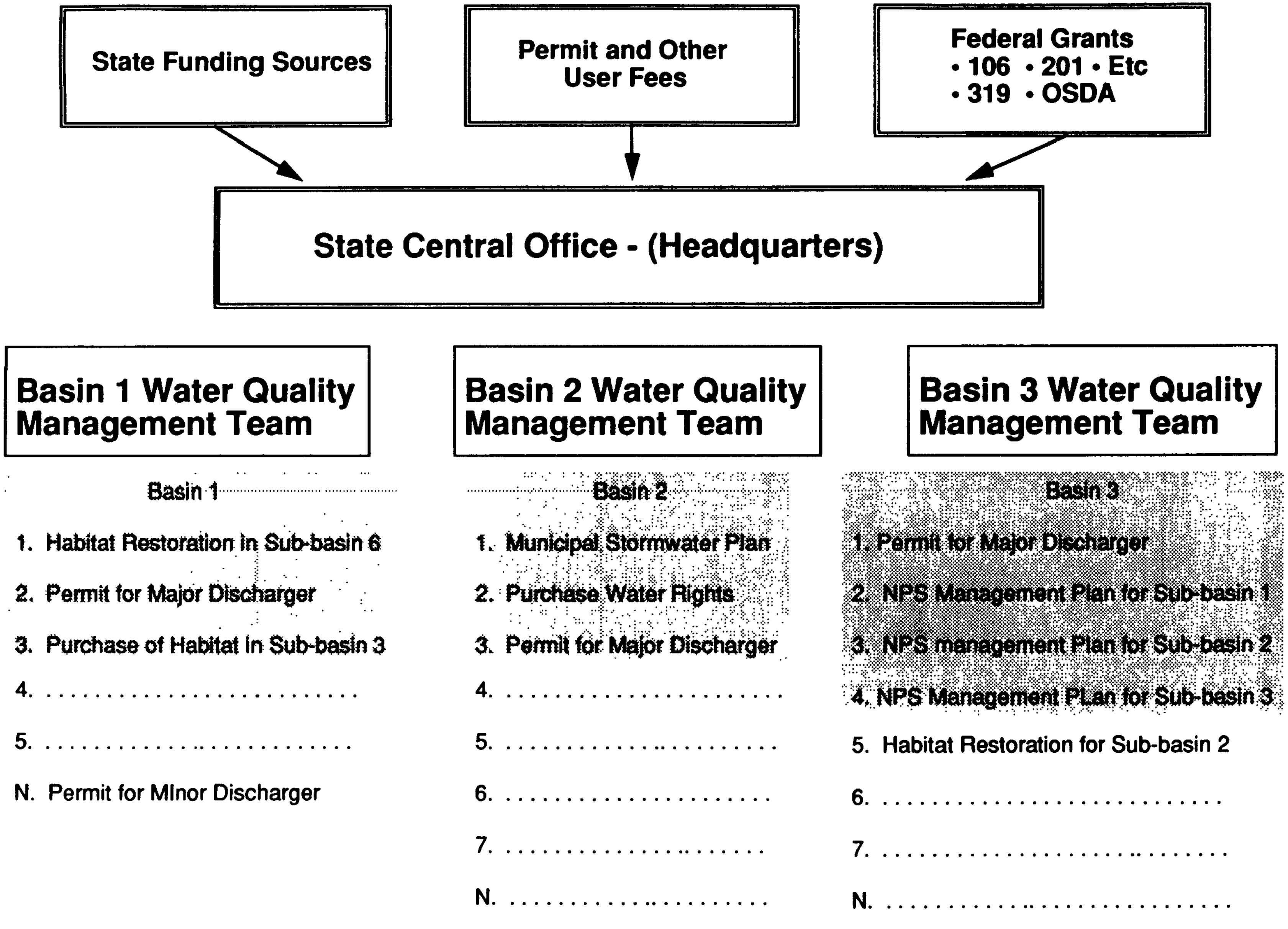



Figure 4.—Relationship of various funding sources to ranking of priority issues.

first iteration of the five-year basin planning cycle. Successive iterations of the five-year planning cycle (Figure 5) establish a long-term management framework to reassess the basin and build upon the efforts of the first cycle.

The source of the problem can be in the watershed, along the riparian or floodplain zone, or in the channels and pools.

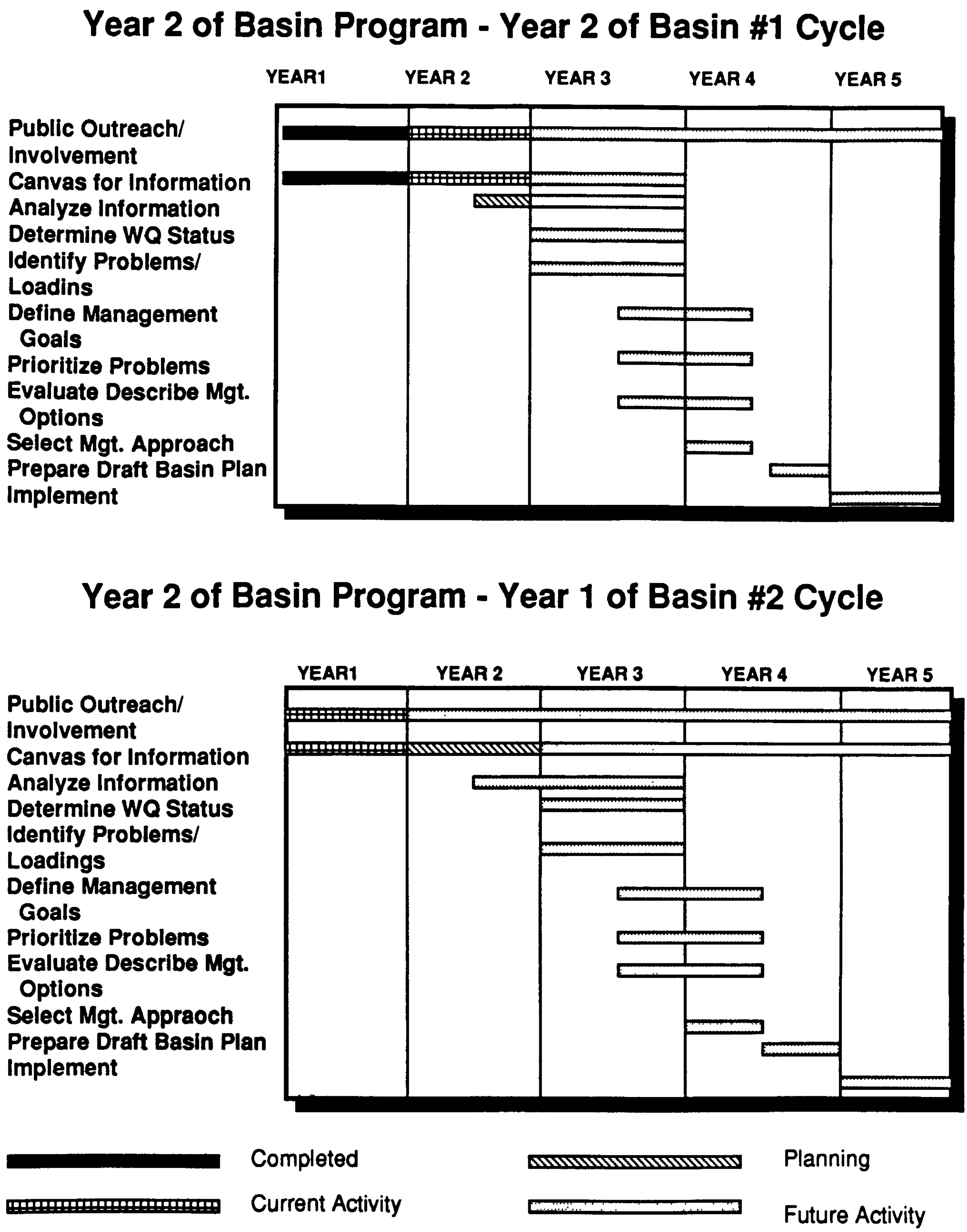
*Stakeholder Involvement:* Recruitment for membership on the basin planning teams for problem analysis and creation of solutions should be broadly based and include all who have an interest in the resource management. Table 2 lists potential candidates for participation on the basin planning team. Successful voluntary compliance programs have demonstrated the importance of including and providing a meaningful role for the potentially affected parties (stakeholders). Their involvement in the plan's development will enhance the implementation of both the voluntary and regulatory components of the basin plan. Stakeholders can also make significant contributions to creative solutions, such as discharger funding of stream restoration projects in return for credits on their permit (e.g., Tar/Pamlico Basin, North Carolina). In addition, other agencies provide a broader mandate for resource management and can also contribute to funding for restoration activities. The manner in which stakeholders are involved may vary from State to State, but it is essential to create consensus on goals and objectives for addressing watershed problems, processes for coordinating implementation activities, and evaluating the efficacy of problem solutions.

*Integrated Solutions:* The basin approach provides a framework to design the optimal mix of water quality management strategies by integrating and coordinating across program and agency boundaries. Integrated solutions implemented by basin management teams use limited resources to address the most significant water quality problems without losing sight and planning for other factors contributing to the re-

**Table 2.—Potential basin plan participants.**

- State environmental, public health, agricultural, and natural resources agencies
- Local/regional boards, commissions, and agencies
- EPA water and other programs
- Other Federal agencies (e.g., USDA-SCS, USDOI, USACOE)
- Tribal representatives
- Public representatives
- Private wildlife and conservation organizations
- Industry representatives
- Academic community

**Figure 5.—Long-term management framework.**



source's degradation. Integration through basin approach provides a means to achieve the short- and long-term goals for the basin by allowing resource application both in a timely and geographically targeted manner. For example, rather than have each program decide independently the basin objectives on a different schedule, the basin receives the combined resources and attention of all water quality program components (and other participating agencies) simultaneously. This helps ensure that problems representing 20 percent of the impact on the resource (low risk stressors) receive 20 percent of the management resources. Integrated solutions are possible because of a framework that encourages an interdisciplinary and interagency team to develop the most appropriate plan, rather than imposing predetermined solutions through rigid application of regulations.

## Section 303(d) Total Maximum Daily Load

Section 303(d) Total Maximum Daily Load (TMDL) provides a central rationale for the water policy agency to assess and regulate on a watershed basis. A TMDL is most often defined as a waterbody's capacity to assimilate pollutants without exceeding water quality standards or impairing the use of the waterbody or its ecological integrity. The assimilative capacity of a stream is often related directly to its physical integrity. As the next section documents, several physical habitat BMPs (in stream and adjoining land) can maintain or restore lost assimilative capacity. Restoration leads to both improved chemical water quality parameters and biological integrity. The focus of most TMDL studies and actions have been pollution control of wasteloads and, secondarily, of NPS loads.

The "Guidance for Water Quality-Based Decisions: The TMDL Process" (U.S. Environ. Prot. Agency, 1991c) has recognized the role of physical habitat in this equation:

> *However, it is becoming increasingly apparent that in some situations water quality standards—particularly designated uses and biocriteria—can only be attained if nonchemical factors such as hydrology, channel morphology, and habitat are also addressed. EPA recognizes that it is appropriate to use the TMDL process to establish control measures for quantifiable nonchemical parameters that are preventing the attainment of water quality standards. Control measures in this case would be developed and implemented to meet a TMDL that addresses these parameters in a manner similar to chemical loads. As methods are developed to address these problems, EPA and the States will incorporate them into the TMDL process.*

The use classification component particularly compels the TMDL process to go beyond traditional water chemistry and investigate use impairment due to habitat constraints. The habitat component can be incorporated into the TMDL process first by including a habitat evaluation component in the "identification of waters" procedure and then subsequently portraying the relative importance of chemical, biological, and physical problems in preventing attainment of use. The next step of the process would be to invest in remediation, which targets the critical factors preventing attainment of use—even if that means setting water quality issues aside to deal with habitat issues. This may not be possible in the current manner in which the CWA is interpreted and implemented in most instances. The current paradigm would require us to improve the water quality, for example, from 20 μg/L Cu down to 15 μg/L Cu even though the impairment due to the 20 μg/L may be negligible compared to habitat constraints.

The information on the number of systems for which physical habitat remediation would be a potential strategy to address both TMDL and impaired use concerns is mostly anecdotal. The instances where restoration would be the optimal strategy are probably numerous across all regions of the country. However, a better estimate of the number of waterbodies that would benefit from physical habitat restoration to put this strategy into a national perspective is needed. This paper presents a potential scoping or screening protocol for evaluating a large number of waterbodies in a basin to identify candidate sites for physical habitat remediation.

The similarities between the basinwide approach and the TMDL process are not coincidental. The basin approach was designed to fulfill both the quantitative and qualitative requirements of the TMDL process. The basinwide approach is an attempt to institute a framework for a risk-based assessment and management program to ensure consistency from one basin to the next and from one State to the next.

## NPDES Stormwater Permitting

The NPDES stormwater permitting provisions of Section 402 of the CWA provides substantial support for restoration of physical habitat of urban waterbodies. EPA's "Results of the Nationwide Urban Runoff Program: Volume I – Final Report" (1982), highlighted the problems associated with the physical aspects of urban runoff. In many of the Nationwide Urban Runoff Program

(NURP) cities, sedimentation and scour were cited as key factors preventing the attainment of aquatic life use. In Bellvue, Washington, "habitat changes (streambed scour and sedimentation) had a more significant effect than pollutant concentrations . . . ." Since sediment is both a water quality and physical habitat parameter of concern, the NPDES stormwater permitting program has a mandate to address urban sedimentation problems. This can be accomplished by requiring the development and application of controls to diminish this problem as part of both the municipal and industrial (construction) permit requirements. The preamble to EPA's stormwater rule mentions that mobilization of sediment from an acre of land under construction is much higher than what is typically coming from an agricultural field. Therefore, sedimentation is part of the charge related to the NPDES stormwater permitting authorities.

### *Other Supporting Components of the CWA*

Many other elements of the CWA support consideration, protection, and restoration of physical habitat and discussing all the supporting components of the CWA is not possible. However, we should briefly note a few of these components. The Antidegradation Policy provides a baseline not only for chemical water quality parameters but also for designated use (and the physical habitat element for both). The section 404(c) provisions for mitigation have provided new opportunities for mitigation/restoration and occasionally preserving important habitat. A recent innovation in the advanced identification of wetlands procedures promotes evaluation of the roles and functions of wetland and riparian habitat in the watershed (Marcus et al. 1992). Nonpoint source programs sponsored through section 319 are recognizing and more frequently implementing a continuum of best management practices (BMPs) from near field (instream) to far-field BMPs to address both the symptom and the cause of poor resource management. EPA's water quality standards criteria program has published methods and guidance on holistic evaluations to allow a state to determine the cause of use impairment. EPA has encouraged a holistic evaluation by discussing and supporting it in a variety of standards and guidance documents including:

- "Water Quality Standards Handbook" (U.S. Environ. Prot. Agency, 1983a)
- "Technical Support Manual: Waterbody Surveys and Assessments for Conducting Use Attainability Analyses" (U.S. Environ. Prot. Agency, 1983b)
- "Technical Support Document for Water Quality-based Toxics Control" (U.S. Environ. Prot. Agency, 1990)

The recent resurgence of the holistic concept is going a step further than the assessments described in these documents. The purpose is to identify those *physical*, biological, and chemical components that are impairing use, and to commit resources and the CWA regulations to actually do something about the preservation and restoration of all these components. In the recent report of the Long's Peak Working Group on National Water Policy (Nat. Resour. Law Center, 1992), many of the nation's leading water quality professionals and public interest group advocates gave a ringing endorsement of this concept.

### *The Montana—Natural Streambed and Land Preservation Act (310) and Stream Protection Act*

The State of Montana has taken an explicit and proactive approach to preserve and protect streams and their riparian habitat. This may be the most cost-effective approach to realize the benefits of intact physical habitat on water quality. The act prohibits any activity in the streambed or in surrounding habitat that would "obstruct, damage, diminish, destroy, change, or modify or vary the natural existing shape and form of any stream its banks or tributaries" without first notifying the State. The State then reviews and approves or disapproves the project. If the project is approved, the State can specify mitigation to diminish any adverse effect from the project. These acts have provisions for fines for individuals found in violation. Amending similar language into the CWA would remove any ambiguity regarding a mandate for physical habitat preservation and restoration.

## Summary of Restoration Techniques and the Water Quality Parameters They Impact

This section discusses the relationships among physical, chemical, and biological habitat and water quality parameters that often adversely affect aquatic life and limit attainable uses in streams. Adequate understanding of these relationships is critical for determining whether habitat restoration and preservation can be used to cost-effectively improve water quality, thus reducing the need for more costly conventional wastewater treatment. A summary is presented in Table 3.

## *Dissolved Oxygen*

Dissolved oxygen (DO) concentrations in surface waters are determined by many factors such as water temperature, salinity, biological respiration, chemical oxygen demand, photosynthesis, and transfer of oxygen into water from the atmosphere. The most important consideration for DO requirements in surface water is minimum concentrations. Minimum DO concentrations in streams occur at night when aquatic plants are not photosynthesizing, but all aquatic organisms, including plants, are respiring. The lowest DO concentrations generally are encountered immediately before dawn. In most streams not receiving significant inputs of materials with high chemical and biological oxygen demand and nutrients that stimulate plant growth and respiration, adequate DO concentrations to support a healthy aquatic community will be maintained by natural reaeration. But in other streams, DO concentrations can be depressed to levels detrimental to aquatic life. Some types of habitat restoration practices that can increase DO concentrations include

- Constructing small hydrologic drop structures to increase reaeration rates.
- Constructing wetlands to intercept nonpoint sources of nutrients, which in turn will reduce aquatic plant growth and respiration demand within the stream.
- Planting trees and bushes along stream banks to reduce incident sunlight and water temperature, which in turn will reduce aquatic plant growth and respiration demands.
- Increasing stream depth, narrowing stream width, and increasing undercut banks to reduce aquatic plant growth and water temperatures, which will reduce respiration demands.

**Table 3.—Relative effect of selected stream habitat restoration practices on some water quality parameters.**

| Restoration Practice | Relative Effect of Restoration Practice on Water Quality | | | | | |
|---|---|---|---|---|---|---|
| | Minimum DO | Temperature | pH | $NH_3$ | Suspended Solids | Bio-available Metals |
| Build Drop Structures | ↑ | O | ↕ | ↓ | ↑ | O |
| Create Wetlands | ↑ | O | ↓ | ↓ | ↓ | ↓ |
| Plant Streambank Trees and Bushes | ↑ | ↓ | ↓ | ↓ | ↓ | O |
| Increase Channel Depth, Narrow Stream Width, Increase Undercut Banks | ↑ | ↓ | ↓ | ↓ | O | O |
| Build Settling Ponds on Tributaries | ↑ | O | ↓ | ↓ | ↓ | ↓ |

## Temperature

Abnormally high water temperatures can adversely impact aquatic life, especially coldwater species such as trout. As discussed in the next section, increases in water temperature also increase un-ionized ammonia concentrations. High water temperatures also contribute to low DO concentrations by increasing plant growth and respiration rates, and decreasing the solubility of oxygen. In most streams with abnormally high water temperatures, the cause is solar heating. The exception to this is waters receiving thermal discharges. In some streams, abnormally low water temperatures can adversely affect warmwater aquatic life, such as in warmwater rivers downstream of dams with hypolimnetic discharges.

Types of habitat restoration practices that can be used to decrease water temperatures include

- Planting trees and bushes along stream banks to reduce incident sunlight.
- Deepening stream depth, narrowing stream width, and increasing undercut banks to reduce solar warming.

## pH

The acidity (pH) of most streams is controlled by the carbonate buffering system. Exceptions to this is streams acidified by strong mineral acids, such as those impacted by acidic precipitation and acid mine drainage, and naturally acidic streams, which are acidic because of organic acids. In most circumneutral streams, pH is controlled by the carbonate system. In most waters with relatively high alkalinity, pH does not vary much. However, in waters with large standing crops of aquatic plants, plant uptake of carbon dioxide during photosynthesis can cause pH levels to rise by several pH units, because carbon dioxide uptake removes carbonic acid from the water. Conversely, during the night when photosynthesis is not occurring and the plants are respiring carbon dioxide, pH levels can fall by several units. All of the habitat restoration practices previously discussed that can be used to increase DO concentrations would also tend to stabilize pH levels:

- Constructing small hydrologic drop structures to increase rate of equilibration of carbon dioxide in water with atmosphere.
- Constructing wetlands to intercept nonpoint sources of nutrients, which in turn will reduce aquatic plant growth and respiration.
- Planting trees and bushes along stream banks to reduce incident sunlight and water temperature, which in turn will reduce aquatic plant growth and respiration.
- Increasing stream depth, narrowing stream width, and increasing undercut banks to reduce aquatic plant growth and water temperatures, which will reduce respiration rates.

## Un-ionized Ammonia

Un-ionized ammonia is the most toxic form of ammonia. Ammonia toxicity often adversely affects aquatic life in streams receiving inadequately treated municipal wastewaters and in streams receiving high loads of ammonia from agricultural runoff and feedlots. Anaerobic decomposition of organic matter can also contribute significant loads of ammonia to streams. The proportion of total ammonia concentration in water present as toxic, un-ionized ammonia is a function of pH and water temperature. As pH and temperature rise, the proportion of un-ionized ammonia increases, and ammonia toxicity increases.

As discussed previously, pH levels in some streams can increase by several units during the day because of carbon dioxide uptake by photosynthesizing plants. This change in pH could potentially cause an increase in un-ionized ammonia concentrations to the point where they become acutely or chronically toxic to aquatic life. Any habitat restoration practice that decreases ammonia inputs, decreases plant growth and standing crops, decreases water temperatures, and/or decreases pH levels will decrease ammonia toxicity. Such practices include

- Constructing wetlands to intercept nonpoint sources of nutrients, which in turn will reduce aquatic plant growth and photosynthesis.
- Planting trees and bushes along stream banks to reduce incident sunlight and water temperature, which in turn will reduce aquatic plant growth and photosynthesis.
- Deepening stream depth, narrowing stream width, and increasing undercut banks to reduce aquatic plant growth and decrease water temperatures.

### Suspended Solids

Abnormally high concentrations of suspended solids are detrimental to most stream ecosystems. However, some aquatic systems where suspended solid concentrations were historically, naturally high—such as the lower Colorado River system—have been adversely impacted by dams that reduced suspended solid concentrations. Habitat restoration practices that can reduce concentrations of suspended solids in streams generally include land use changes to reduce the sources of sediments and the building of wetlands and ponds to intercept nonpoint sources of sediments.

### Metals

The toxic effects of metals to aquatic life in streams depend on metals' concentrations and the interactions of several water quality factors that affect the bioavailability of metals. Since the primary pathway for most metal uptake is through the gills and only ionic forms can pass through gill membranes, the toxicity of most metals to aquatic life is a function of the concentration of ionic forms of metals present. Consequently, metals present as particulates are not directly toxic to aquatic life. Water quality parameters that reduce the bioavailability of metals to aquatic life include dissolved and particulate organic carbon, alkalinity, and other ligands that complex metals, reducing ionic forms. Calcium also reduces metal toxicity by reducing metal uptake.

Any habitat restoration practice that reduces inputs of metals to streams and/or produces increases in water quality factors that reduce metal bioavailability will decrease the toxicity of metals to aquatic life. Use of created wetlands to treat acid mine drainage is a good example of such a practice. Wetlands can reduce metal inputs and increase inputs of dissolved organic carbon and alkalinity concentrations to streams, all of which reduce metal toxicities.

### Minimum Flows

A final "water quality" factor affected by habitat restorations is the quantity of water maintained in streams. In many U.S. arid regions, stream segments are periodically dewatered from irrigation, industrial, and municipal withdrawals, evaporation, and groundwater infiltration. Conversely, flow in many streams is comprised primarily or entirely of treated wastewater and irrigation return flows. In such streams, the entire aquatic and riparian ecosystem is maintained by wastewater and irrigation flows. Due to the high cost of conventional wastewater treatment needed to meet ever more stringent effluent limits and water quality standards, and the high value of water in these arid regions, many municipalities are planning or already have implemented plans to use most or all of their wastewater. The end result is the loss of entire aquatic and riparian ecosystems. In some situations, considering the restoration and preservation of such ecosystems use of the water may be environmentally beneficial and cost effective.

## Scoping of Eligible Systems

### Background

Several approaches may be taken to determine the potential benefits of ecological restoration within a geographic area. To assess potential benefits for a given area, the important questions are

- What is the extent of habitat degradation (*e.g.*, proportion of stream miles within the study area)?
- What measurable impairment of beneficial uses can be associated with the habitat degradation?
- What improvement in attaining beneficial uses could be made through ecological restoration and at what cost relative to technology-based controls?

Ideally, we would want to identify the specific regional stream and river areas where habitat degradation exists, examine the violations of water quality criteria and impairment of beneficial uses attributable to this degradation, and assess the cost effectiveness of remediation expected through ecological restoration for each site. Unfortunately, undertaking such an approach on an exhaustive basis is not feasible at this stage, as this would require detailed physical and ecological studies of each waterbody with expected impact. More general estimation methods are needed for an initial scoping of potential benefits.

The initial scoping must use available databases to provide the first cut at assessment. Unfortunately, direct measures of the degree of habitat degradation are not readily available for most streams; therefore, we need to get at the problem through an indirect course. One natural approach is to use extant studies, which provide information on physical habitat degradation and associated impairment of beneficial uses. These include 305(b) reports, 319 assessment reports, use attainability analyses, and other sources as discussed later in this section. In many cases, these studies will provide detailed summaries of habitat suitability measures and water quality parameters related to habitat degradation. Such a survey can yield valuable information on the prospective benefits of habitat restoration and associated costs. However, it does not provide a balanced picture of a whole region. That is, use attainability analyses and other such studies, by their nature, focus on areas where impacts may be significant, either due to the magnitude of stressors or resource sensitivity. Thus, analysis of these studies cannot provide an unbiased picture of potential benefits of regional ecological restoration. An alternative approach to scoping the problem is to survey the distribution of water quality parameters frequently *associated* with habitat degradation. This is an indirect approach, as a causal relationship between water quality excursions and habitat degradation cannot be generally established from the data available. However, it does provide a useful initial scoping of the problem's magnitude.

We advocate following both approaches for scoping the potential regional benefits of ecological restoration. Site specific studies will yield evidence on cost effectiveness of individual projects, while examining relevant water quality parameters on an area-wide basis will help gauge the general applicability of the approach.

At this stage we have undertaken the preliminary aspects of both approaches, as applied to potential benefits of habitat restoration in Colorado streams. We can present the proposed methodology and some preliminary results at this time. The project's next phase will include more detailed work in both areas.

## Area-Wide Scoping

We attempt to devise a protocol for the area-wide scoping of the stream segment proportions that may benefit from habitat restoration. This cannot be accomplished explicitly, as habitat status indices in stream segments are not available in extensive aerial coverage. On the other hand, USGS and other agencies measure basic water quality parameters regularly for a large number of stations. These are available on EPA's STORET system. If basic water quality parameters that correlate with habitat degradation are identified, querying of these data on STORET can yield a preliminary indication of the proportion of stream miles that might benefit from ecological restoration.

This approach is, of course, only a rough screening tool. As STORET does not record a variable for "habitat degradation," we cannot ascertain when the water quality standard excursions are actually correlated with habitat degradation or due to other causes and if a site is amenable to habitat restoration. Essentially, this approach yields a first candidate list of potential restoration areas, which then must be refined through more detailed study to identify areas likely to benefit from the approach. Scoping is simply to obtain an order of magnitude indication of the problem's extent.

To test and demonstrate this approach, we chose a specific geographic area—the South Platte River drainage portion of Colorado. This comprises approximately the State's northeast quadrant and includes a number of rivers on which detailed studies have been undertaken. Because STORET contains data on many types of waterbodies, we further restricted the search to include only ambient stream stations. We also excluded stations that reported neither instantaneous or mean flow, since ecological restoration techniques are only likely applicable below a certain critical stream size (a median flow of 1500 cfs was the arbitrary cutoff). Finally, we also restricted the search to records from 1979 to present.

With these restrictions, STORET yielded records of 190 water quality stations within Colorado's South Platte River drainage, the bulk of which were USGS water quality stations, with 42,823 observations. These stations formed the basis for our analysis.

We have previously discussed important water quality parameters correlated with habitat degradation, including DO, temperature, pH, un-ionized ammonia, suspended solids, and toxic metals. Of these parameters, toxic metals were judged not appropriate for area-wide scoping because of too much local variability in toxicity from interaction with other water quality variables. Data on suspended solids are available on STORET; however, this parameter is highly dependent on local variability of conditions, and Colorado has established no numerical criteria. The other parameters do have numerical criteria against which standard violations may be assessed. These are established for both coldwater and warmwater fisheries (see Table 4).

From this parameter list, un-ionized ammonia presents an additional problem. That is, although a standard exists, it is not usually measured directly in the field but rather calculated from total ammonia, temperature and pH. It is usually not reported in STORET, and so it cannot be screened without performing the calculations. The equation for calculating un-ionized ammonia as nitrogen ($NH_3$-N, mg/L) is

$$NH_3 - N\,(mg/L) = \frac{X}{1+10^{(pK_h - pH)}}$$

**where**

X is the measured quantity of total ammonia (mg/L-N),

$pK_h = 0.09018 + 2729.92/(T+273.2)$, and

T is temperature in °C.

*(Bowie et al. 1985)*

At present we have not completed the necessary data manipulation to study un-ionized ammonia on the scoping data set. The distribution of the other parameters over all stations retrieved is shown in Table 5 (including STORET parameter identification code).

All 190 stations were analyzed for violations of water quality standards for the three parameters listed in Table 5, using the STORET routine STAND. This first required a determination of whether coldwater or warmwater fishery standards applied to a given station. In Colorado, the

**Table 4.—CO numerical criteria for coldwater and warmwater fisheries.**

| | Coldwater | Warmwater |
|---|---|---|
| Dissolved Oxygen | 6 mg/L (7 for spawning) | 5 mg/L |
| Temperature | 20° C max., 3° increase | 30° C max, 3° increase |
| pH | 6.5 min., 9.0 max. | 6.5 min., 9.0 max. |
| Unionized Ammonia | .02 mg/L $NH_3$-N (30-day average) | .06 mg/L $NH_3$-N (30-day average) |

**Table 5.—Statistical distribution of retrieved parameters.**

| | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Dissolved Oxygen (mg/L) (00300) | 9.34 | 4.86 | 0.08 | 20.0 |
| Temperature °C (00010) | 10.0 | 7.02 | -1.0 | 65.0 |
| pH (00400) | 7.68 | 0.83 | 0.0 | 11.7 |

delineation between these zones is roughly mountain/plains boundary. Rather than identify each station explicitly, we obtained a close approximation of the appropriate data set by setting the delineation between the two zones at 105° west longitude.

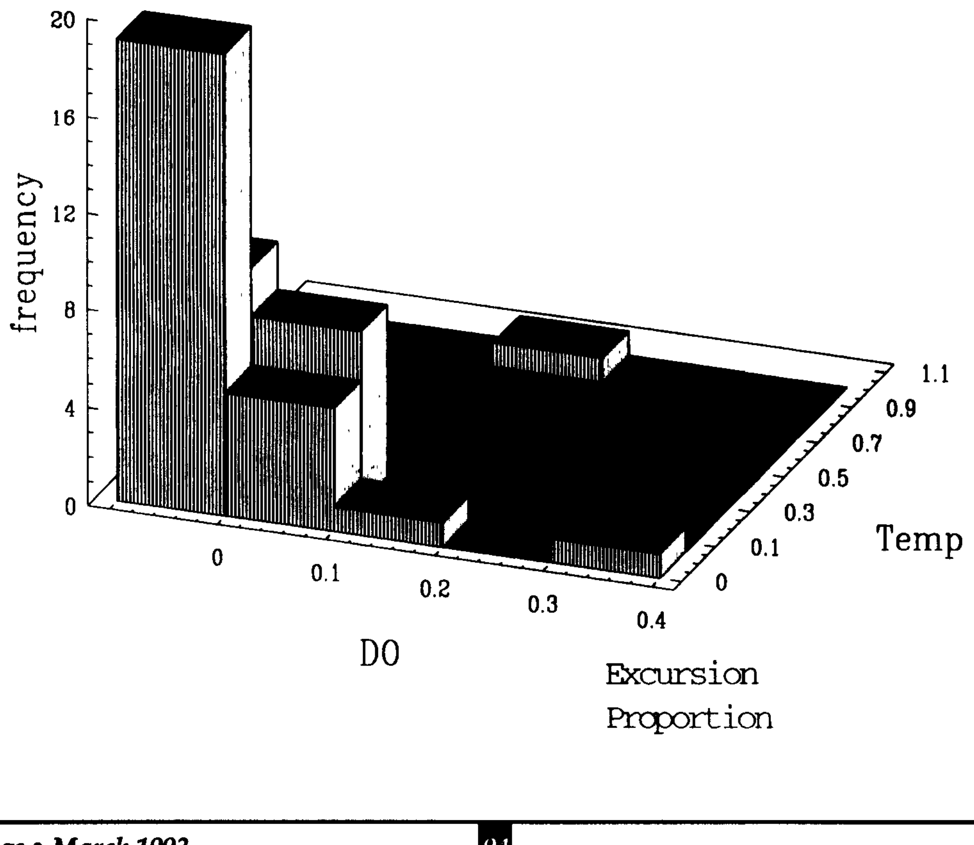
Data on the parameters of interest was available for 258 out of the 290 stations processed. Of these, no violations of standards were *reported* at 169 of 258 stations (not all parameters were measured at every station). Thus approximately one-third of water quality stations in this part of Colorado showed at least occasional excursions of water quality standards related to habitat degradation.

The 89 stations where at least one standard of interest was violated represent the initial scoping data set for potential habitat restoration. At those stations where violations were found, 64 percent had excursions above temperature criteria, 58 percent had excursions outside pH criteria, and 32 percent had excursions below dissolved oxygen criteria. However, only 13 percent of the stations where violations were found had violations in all three parameters. This wholly reflects lack of correlation between DO and pH violations, presumably because pH excursions may result from acid loading without involving other physical habitat impacts. Twenty percent of the stations in violation had both temperature and pH violations, while 23 percent had both dissolved oxygen and temperature violations. This finding suggests that, at least for Colorado, temperature and dissolved oxygen (and also probably un-ionized ammonia) may be the most important indicator parameters for scoping potential for ecological restoration.

Figure 6 shows the joint histogram of temperature and dissolved oxygen percent violations for all stations at which a violation in pH, temperature, or dissolved oxygen was noted. The 11 stations identified with violations in both temperature and dissolved oxygen are

- South Platte River at Englewood
- South Platte River at Littleton
- Schwartzwalder Mine Effluent near Plainview
- St. Vrain Creek below Longmont
- Coal Creek near Plainview
- Big Thompson River below Loveland
- Carter Lake near Berthoud

**Figure 6.—DO and temperature—proportion of measurements in excursion of standards (South Platte River Watershed, CO sites with recorded DO, temperature or pH excursions).**



- Cache la Poudre River at Shields St. at Fort Collins
- Cache la Poudre River above Boxelder Creek near Timnath
- Cache la Poudre River below Fort Collins
- South Platte River at Julesburg

Several locations identified here will also be discussed in a later paper that includes site-specific studies examining the correlation of physical habitat condition factors with water quality data. These studies will also allow a closer examination of the range and extent of benefits (e.g., employment, recreation, fish habitat) associated with physical habitat restoration projects. These studies will extend scoping strategies for identifying candidate waterbodies for physical habitat remediation using 305(b) reports, 319 assessment reports, habitat suitability curves/indices, use attainability analyses, and limiting factors.

## Case Study—Improvement Studies for Segment 15 of the South Platte River

### *Candidacy for Ecological Restoration*

Segment 15 of the South Platte River is both water-quality and habitat limited. Previously, water quality and aquatic life were impaired by high concentrations of chlorine and ammonia from a municipal wastewater treatment plant (WWTP) effluent. However, the effluent is now dechlorinated and ammonia concentrations have been greatly reduced. Presently, water quality may be limited by low dissolved oxygen concentrations. Physical habitat limitations include fish barriers and poor instream habitat. These water quality and habitat limitations have prompted managers and regulators to evaluate measures that may improve water quality within the segment through habitat improvement or increased wastewater treatment. To accomplish this, extensive data on the segment's physical, chemical, and biological characteristics have been generated to examine habitat restoration benefits versus wastewater treatment to improve water quality. We believe that the studies and proposed habitat improvements in Segment 15 are appropriate as a potential case study for water quality improvements through habitat restoration. And Segment 15 studies should provide the basic framework for a comparison of conventional WWTP and habitat approaches to improving water quality.

### *Description of the Problem*

The South Platte River serves as a water source for agriculture, municipalities, and industries, and as a receiving water for wastewater. During the summer months, the river flow is augmented by a wastewater discharge, which can make up to 95 percent of the river flow. Because the river flow is augmented with a nutrient-rich discharge and flow is seriously reduced by numerous irrigation diversions, portions of the river in Segment 15 experience low DO concentrations, such that the DO concentrations do not meet the State standards. Habitat in the river previously has been degraded from stream channelization and fish barriers.

### *Scope of Work*

Camp Dresser & McKee, Inc. and its subcontractors, the Cadmus Group, Habitech, and WEST, Inc., are conducting scientific and special studies for Segment 15 of the South Platte River to develop a site-specific dissolved oxygen standard for the segment. The work is being done for the Metro Wastewater Reclamation District (Metro) with close cooperation and interaction with Region VIII of the U.S. Environmental Protection Agency, the Colorado Department of Health, and the Colorado Division of Wildlife through the Scientific Advisory Team (STAT) that includes the participation of all these entities.

According to STAT, development of a site-specific standard is justified if the standard protects all fish species that could successfully inhabit the segment if DO is not the limiting factor. STAT also agreed that the primary focus of the protection of fish species should be on species indigenous to the segment.

### *Scientific and Special Studies*

Studies directly and indirectly associated with developing a site-specific DO standard for Segment 15 include assessments of (1) the relationship between low DO concentrations and the resident fish community, (2) the effects of low DO concentrations to specific species in laboratory tests, (3) the potential effects of ambient and episodic toxicity as confounding factors, (4) the physical habitat influence on fish within the segment, and (5) the influence of biological oxygen demand, sediment oxygen demand, and the groundwater on DO concentrations. In addition, modelling exercises are being conducted to determine the effects of alternative instream modifications (e.g., drop structures) to DO reaeration rates.

## Alternatives

Habitat improvements may include channel modifications, wetlands mitigation, replacing the existing drop structure, and filling in existing pools. Habitat improvements will benefit aquatic life by increasing stream DO concentrations and providing more small structures in the stream.

The alternative to the Segment 15 improvements is to upgrade Metro's facility. Upgrading the facility would include building and maintaining additional nitrification capacity. The upgrade process would further remove ammonia from the effluent, thus reducing the oxygen demand required for microbial oxidation of ammonia to nitrite and nitrate.

## Cost

The cost differences between the habitat restoration approach versus the WWTP approach are large (Table 6). Estimated costs of building and maintaining the treatment plant upgrade could run in excess of $112 million. On the other hand, the cost of the recommended studies and habitat improvements could be less than $10 million for one segment site. As indicated in Table 6, the potential for further improvements in the river at $10 million increments are extensive.

# Implementation Issues

*Amendment of the CWA:* We have previously described the substantial mandate that exists within the CWA for addressing physical habitat restoration and preservation. However, the mandate is still subject to interpretation because it is rarely stated explicitly. The Montana Streambed Protection Act and the Natural Streambed and Land Preservation Act (310) contain language consistent with the intent of the CWA (section 101(a)) and give explicit direction to the program. The language does not, however, help to change the traditional practices and use that have led to such widespread degradation of physical habitat along stream and river corridors.

*Institutional Funding Procedures:* Figure 4 illustrates a highly idealized environmental ranking and funding scenario. Institutional barriers to the allocation of grant funding on a risk-based approach places severe restrictions on the funding of ecological restoration projects. If States establish an objective basin approach framework for developing basin plans, perhaps program auditing requirements can be relaxed to allow the distribution of funds based on basin priorities rather than strict program spending formulas.

*Long-term commitment:* Physical habitat restoration rarely leads to rapid (one to two years) results. Oftentimes remediation requires five years to become established and show results. Policymakers and the public often have a shorter planning horizon than required to heal impaired waterbodies. This limitation can potentially be addressed through an aggressive public outreach and education component of the basin-wide approach program.

*Absence of restoration verification data:* Post-restoration monitoring data to demonstrate the recovery of waterbody integrity is scarce. Selling large programs on the basis of a conceptual model alone is difficult. Restoration projects

**Table 6.— Approximate costs of a treatment upgrade versus habitat improvements.**

| Activity | Improvement Cost | Upgrade Cost |
|---|---|---|
| Recommended Improvements | $6.6 million (cost can vary -50% to +100% from final construction costs) | |
| Phase I studies | $1.4 million | |
| Phase II studies | $2.0 million | |
| Treatment upgrade | | $112.0 million |
| Total | $10.0 million | $112.0 million |

generally pour every dollar into remediation without setting any money aside for baseline or post-project monitoring. Pilot projects should be funded that require monitoring funds to be set aside to address the absence of any sort of validation information measuring the impact of restoration projects.

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*PANEL: Policy and Management Approaches for Restoration*

# *Reinvest In Minnesota: A State's Approach to Ecological Restoration*

David H. Behm

*Minnesota Board of Water and Soil Resources*
*St. Paul, Minnesota*

You have previously heard about a wealth of opportunity with voluntary programs, an incentive approach, and an education approach to making ecological restoration really happen. These are real opportunities to open some doors.

## Pristine Versus Common Sense

Minnesota is not made up of millions and millions of acres of backwoods wilderness area; in fact, most of the state is heavily influenced by agriculture. Hence, the program I will cover is geared toward the agricultural community. Dr. Jordan commented that we should live in an ecosystem that we want to restore. We need to keep in mind that we cannot always achieve pristine restorations and that we must take a common sense approach to restoration.

RIM stands for Reinvest In Minnesota. In 1984, then Governor Rudy Perpich established a citizens' committee to determine the significance and importance of the tourism industry by looking at the revenues from fishing and hunting. The commission found that fishing and hunting were very important industries, adding over a billion dollars annually to the economy.

The commission also found a great deal of soil erosion going on and water quality impacts that affected the fisheries. Most of the wetlands, particularly in the agricultural areas, had long been obliterated by the agricultural interests that largely support the state's economy. Therefore, we cannot restore or create or enhance wetlands to the extent we once had them in Minnesota. The commission recognized that we also needed a strong economy to attract visitors.

Consequently, the commission drew a parallel between private industry's growth and capital reinvestment. In other words, the commission recommended we reinvest in Minnesota—reinvest in our resources to sustain fishable waters and fisheries (particularly the walleye).

## Protecting Soil and Water

A key point that underlies the whole concept of RIM is that the commission realized that it could not merely start planting trees and native grasses—it needed to first protect soil and water resources. It outlined an ambitious 10-year, $600 million proposal. Using the state's 6 percent sales tax as a basis of comparison, the amount suggested to annually reinvest was $60 million dollars. The commission specifically recommended that $150 million dollars be reinvested in land and water conservation. In recognizing that 75 percent of the state is privately owned, with most of the land in agricultural production, the commission recommended that conservation is where most of the activities and programs had to be focused.

Other things were also going on at the time. In the mid-'80s, the Midwest was experiencing a farm economic crisis, with farm foreclosures and farm aid concerts commonplace. Helping the human resource meant providing large amounts of capital to keep people on the land and to reinvest in better lands by removing marginal lands from production. This is the basis of RIM Reserve—a conservation easement program for private lands.

## Partnerships Critical

We have heard about the importance of partnerships to initiate incentive programs, particularly those based on voluntary efforts. Many people with different perspectives and different interests must be involved to provide the opportunity for consensus building. In reaching a consensus, no one gets exactly what they want, but everyone gets something. The results have been noteworthy restorations. This is where private interest groups, and their willingness to contribute substantial dollars, come in.

Partnerships are very important. Our program has shown that partners are interested, involved, and want to help. Some organizations—Ducks Unlimited, for example—have seen the handwriting on the wall and no longer have a single-issue focus. These organizations are also talking about water quality and restoration of ecosystems. Do not count them out because of a name only.

RIM Reserve also provides some cost sharing. We believe in reinvesting because of the long-term or even perpetual interest we have acquired in land; we know our investment will be safe and sound. At times, we pay a premium to do so, but the investment is worth it.

## For the Public Benefit

Eligible lands for RIM Reserve include riparian lands, restorable drained wetlands, and highly erodible marginal agricultural soils. We take these lands for a variety of reasons, one of which is the public benefit. RIM Reserve is geared toward private landowners, offering an incentive payment in exchange for a conservation easement conveyed to the state. In the first year, nearly all of the enrollments were 10-year easements. Since then, the limited duration easements have been changed to 20-years. In the last three years, we have only offered perpetual easements because of the overwhelming response from landowners. In fact, we have received twice as many requests for dollars than dollars available.

## Appendix: Reinvest In Minnesota

### *Background of Reinvest In Minnesota (RIM)*

#### ■ Why did the bill evolve?

- In 1984, Governor Perpich establishes citizens commission to promote hunting and fishing

- Commission found that hunting/fishing and other wildlife-related activities contribute over $1 billion to state's economy

- Commission also learned

  147 million tons of soil erode annually—equivalent of 73,000 pounds for every man, woman and child in Minnesota; much eroded soil ends up in streams and lakes in the "Land of 10,000 Lakes"

  85 percent of wetlands had been lost to development or conversion to cropland

  Income from fishing/hunting licenses had not kept pace with need to resolve numerous fisheries/wildlife management issues

- Consequently, commission drew a parallel between private industry's growth by capital reinvestment and Minnesota's tourism industry

- Accordingly, commission's report concluded that for Minnesota's economy to continue to benefit from fish/wildlife related tourism and to protect our natural heritage, the state needed to annually "reinvest" $60 million (equivalent of 6 percent sales tax from its $1 billion tourism industry) into soil, water, fish, and wildlife programs

  Commission outlined an 11-point, $600 million reinvestment plan for the decade ahead

| | |
|---|---|
| Planning/administration | $15 million |
| Research | $39 million |
| Special surveys | $16 million |
| Habitat development | $131 million |
| Land and water conservation | $150 million |
| Habitat protection | $24 million |
| Wildlife, spawning, and trout stream acquisition | $130 million |
| Fish culture | $26 million |
| Information/education | $12 million |
| Resource law enforcement/protection | $60 million |

Commission recognized that any improvements on private agricultural land for the sake of enhancing fish and wildlife habitats would have to begin with providing adequately protected soil and water resources

- **Why did the bill pass?**
  - Early to mid-1980s was depth of recent agricultural economic crisis (e.g., farm foreclosures, FarmAid benefit concerts, etc.)
  - After commission report made public in 1985, a coalition of sporting, environmental, conservation, and agricultural groups (e.g., Audubon Society, Pheasants Forever, Ducks Unlimited, Walleyes Unlimited, Minnesota Corn Growers Association, Minnesota Association of Soil and Water Conservation Districts, Nature Conservancy, Izaak Walton League) was formed to lobby for passage of a bill—it did so with only six dissenting votes
  - RIM Coalition sought adequate funding in 1986—their efforts resulted in a $16 million appropriation
  - RIM Coalition and passage of RIM Act was likely due as much to national trends and discussions (e.g., 1985 Farm Bill, Conservation Reserve Program) as to specific activities within Minnesota
- **Purposes of RIM Act**
  - Keep certain marginal agricultural land out of crop production or pasture to protect soil and water quality and support fish and wildlife habitat
  - Fish and wildlife are renewable natural resources to be conserved and enhanced through planned scientific management, protection, and utilization

## *RIM Incentives for Restoration*

- **RIM Reserve Program**

  *Perspectives (private lands)*
  - Analogy with Conservation Reserve Program was quickly and easily made; however, easements rather than contracts were viewed as best method to acquire long-term interest in property and to further justify funding source of state bonds
  - Offers private landowners an incentive payment in exchange for a conservation easement, typically in perpetuity
  - Also offers cost-sharing to establish permanent vegetative cover practices, with intention of providing 100 percent reimbursement of actual costs, but limited to specific rates (e.g., $100 per acre for grasses/legumes, $300 per acre for trees/shrubs or wetland restorations)
- **RIM Wildlife Habitat Improvement Program**

  *Perspectives (private lands)*
  - Offers private landowners cost-sharing (50-100 percent) to restore wetlands, establish permanent vegetative cover, especially native grasses and plantings of shrubs and trees for pheasant cover
- **RIM Critical Habitat Match Program**

  *Perspectives (public lands)*
  - Provides an opportunity for the private sector to help fund the cost of acquiring, improving, and restoring fish and wildlife and native plant habitats; state funds are matched dollar-for-dollar by private donations of land, interests in land, and cash

## *Restoration: Cost-Effectiveness and Financing Opportunities*

*Perspectives*

- RIM Programs have been evolving since initial passage
- With evolution comes acknowledgement of resource needs/issues (e.g., sensitive groundwater areas) and funding considerations (e.g., extending limited duration easements from 10 years to 20 years due to payment on bonds; then funding only perpetual easements with limited available easement acquisition funds)
- Since underlying premise is that reinvestment in natural resources was essential to sustaining a billion dollar hunting/fishing tourism industry, coupled with political and social issues regarding farm economic crisis, the justification for "cost-effectiveness" has never truly been micro-analyzed—state simply believes that such reinvestment is required and that, through internal controls (e.g., legislative and administrative), the effectiveness and efficiency of acquiring interests in property (fee simple as well as perpetual easements) has not required such analysis

- Consequently, while we have likely paid premium prices for acquisitions, we believed that acquiring perpetual easement or fee simple interests in properties for program purposes essentially guarantees that overall benefits-to-costs exceed 1:1; furthermore, this may be true largely due to extensive screening of parcels offered for enrollment
- Restoration costs depend on the ecosystem to be "restored" and the extent of restoration (i.e., true "restoration" versus "enhancement")
- Ongoing maintenance costs for upkeep of restored ecosystems will be large since such areas are now merely remnants and surrounded by intensively used landscape consisting of numerous highly competitive species of flora and fauna

## Wetlands Restoration Costs

- RIM Reserve Program statutory cost-sharing limits (100 percent, up to $300 per acre)
- Average wetland restoration practice costs = $340 per acre; $3,400 per project; 10-acre average
- Range of wetland restoration practice costs = $10 per acre to $1,700 per acre
- RIM Reserve wetland restoration easement costs = $1,257 per acre (easement + practices + administration)
- RIM Reserve easement costs (all categories) = $858 per acre (easement + practices + administration; administration = 16 percent of total costs)

## Prairie Restoration Costs

- RIM Reserve Program statutory cost-sharing limits (100 percent for perpetual, up to $100 per acre; 75 percent for limited, up to $75 per acre)
- Average native grass establishment costs = $95 per acre; $1,520 per project; 16-acre average
- Range of native grass establishment costs = $36 per acre to $261 per acre
- Average prairie restoration practice costs = (from RIM CHM and RIM WHIP) $800 per acre to $10,000 per acre depending upon acreage and diversity of species

## Financing Opportunities

*State General Fund*

- RIM Reserve Program = $1.8 million for FY92/93 for administration
- RIM Wildlife Habitat Improvement Program = $350,000 for FY92/93
- RIM Critical Habitat Match Program = $0 for FY92/93

*State Environmental Trust Fund*

- RIM Reserve Program = $1.0 million for FY92/93
- RIM Wildlife Habitat Improvement Program = $0 for FY92/93
- RIM Critical Habitat Match Program = $0 for FY92/93

*State Bonding Initiatives*

- RIM Reserve Program = $8.15 million for FY92/93
- RIM Wildlife Habitat Improvement Program = $0 for FY92/93
- RIM Critical Habitat Match Program = $3.0 million for FY92/93

*Private funds*

- RIM Reserve Program = $185,000 for FY92/93
- RIM Wildlife Habitat Improvement Program = N/A for FY92/93
- RIM Critical Habitat Match Program = $3.0 million for FY92/93

*Federal funds*

- RIM Reserve Program = $2.363 million for FY92/93
- RIM Wildlife Habitat Improvement Program = $0 for FY92/93
- RIM Critical Habitat Match Program = $0 for FY92/93

## Program Integration for Successful Restorations: RIM Reserve Program

■ **BWSR Strategic Plan**

- Program should be available to protect or retire all existing marginal agricultural and highly sensitive lands
- Land retirement programs should be targeted to the highest priority marginal agricultural and sensitive lands
- Retired marginal agricultural lands with severe erosion potential should not be brought back into agricultural production unless effectively managed to prevent excessive soil loss
- Retirement of marginal agricultural lands and highly sensitive lands will permit land managers to focus their stewardship efforts on more productive lands

■ **Five-Year Program Plan**

- Protection of groundwater quality shall be given priority over the improvement of state and locally designated surface water resources
- Highest priority for marginal agricultural lands shall be for those lands in land capability classes V through VIII, followed by capability class IV, followed by other specifically designated classes and subclasses
- Each parcel enrolled shall have a conservation plan developed to ensure adequate habitat enhancements for fish and wildlife species, but particularly with a priority for endangered or threatened flora or fauna species where the land has such capability, and generally followed by fish species, and lastly followed by any game species of wildlife

■ **Comprehensive Local Water Plans**

- Local inventories of some types of eligible lands
- Locally prioritized watersheds in need of land management
- Local recommendations on legislative and administrative revisions to program ❑

## PANEL: Policy and Management Approaches for Restoration

# General Panel Discussion

Dennis M. King
*International Institute for Ecological Economics*
*University of Maryland*
*Solomons, Maryland*

Daniel Willard
*Indiana University*
*Bloomington, Indiana*

Steve Eggers
*U.S. Army Corps of Engineers*
*St. Paul, Minnesota*

Clayton Creager
*The Cadmus Group*
*Petaluma, California*

David H. Behm
*Minnesota Board of Water and Soil Resources*
*St. Paul, Minnesota*

**Question:** You discussed the economic costs and relatively low quality and probability of things turning out. The implication was that with low cost you always end up with low quality. Are you making that argument?

■ **Answer—Dennis King:** Not always but most of the time. Up to some point, as you did tasks to a project or do a better job of completing certain tasks, your results will improve. And most new tasks and improved procedures will increase costs. So, in general, yes.

Like most of us, restorationists do not want to spend any more than necessary to achieve a given level of functional recovery. They operate on the "efficient frontiers" where the only way to get more results is to spend more. Some bargains are out there. But even with them, if you try to lower costs too much, performance suffers.

■ **Question:** We conducted an extensive study in Illinois to look at permits, identify mitigation requirements, and follow up. One of the biggest problems is that once permits are issued, there is no follow-up. The agencies issuing the permits do not have the staff or the resources to even evaluate whether or not the permit conditions are met. I would appreciate a comment, because you have just demonstrated something interesting.

■ **Answer—Steve Eggers:** I agree with you 100 percent. Follow-up on the mitigation sites is a major problem and revolves around staffing and budget. We are trying to improve on that, but staff keeps getting cut back. We have required more monitoring by permittees.

■ **Question:** What is your opinion of mitigation banks to ensure that mitigation is working before the project is built?

■ **Answer—Steve Eggers:** The primary advantage of banks is that you can see beforehand the functions and values that will be replaced. Before bank credits can be accepted, you must have a successfully functioning wetland—a primary advantage over other projects. In specific mitigation, the work is done in conjunction with the authorized firm. We are not sure if this will work.

■ **Comment—Dennis King:** Interest continues in entrepreneurial banks, private banks, getting the government out, and letting business take over. Our preliminary work shows little chance of finding an entrepreneur willing to invest in a mitigation bank if the product is not marketable until after it fully functions to the satisfaction of the various competing agencies.

The advantage to the environmental community of fully functional replacements before it can sell is absolutely out of the question from an entrepreneurial viewpoint. This means the government must bear those risks.

■ **Question:** Regarding the lack of governmental standards on acceptable wetlands, you mentioned that before you can accept a wetland credit, you must certify that it is, in fact, a functioning wetland. Is that a back-door way for the government to make an up-front decision about criteria for an acceptable wetland? It works on the failure of government, not on success.

■ **Answer—Steve Eggers:** The primary advantage of mitigation banks is that we know up front what has been established, its functions, and its success. If we take that away and accept banks that are not constructed properly—without the proper vegetation or with other problems—then the governmental agencies may not find banking acceptable. In that case, why not stick to project specific mitigation?

■ **Comment:** It all feeds back to the different regulatory processes. A certain amount of avoidable risk occurs in allowing a credit to be used before it is fully functioning. If we decide collectively to accept the risk, just like the private sector, we want some net gain or payoff. The payoff will be in defining a watershed plan, setting up priorities, and aiming for net gain instead of no net loss. You can probably convince the regulators to accept that risk.

In looking at the whole watershed and overlaying existing data, you will see targets of opportunity providing the greatest amount of function and the greatest probability of sustainable success. You develop mitigation sites based on local geographic mandates—thinking in a proactive way rather than being caught off guard when presented with a piece of land that looks like a target. You can say, "Wait? We have that figured out. We need you help on this watershed-wide project."

Bigger is often better. Places where the hydrology is intact are more likely to be successful. With environmental change continuing, we must get out in front. I believe in global and climatic change, though I am unsure of the rate. You must think, "How will this wetland or this project fit into the watershed context 20 years from now?" You want to build with that kind of thinking.

■ **Question:** Steve mentioned that the species diversity after one year was not radically different from the adjacent unaltered wetlands. Is that the result of an intensive study? What species did not radically or quickly repopulate in the created wetland? And what was the effect of nonindigenous species in the created wetland?

■ **Answer—Steve Eggers:** Wispark was an exception. It was one of the few mitigation plans approved in the 1980s (by the St. Paul District) where both qualitative and quantitative vegetation data has been gathered. This data forms the basis for my statement that the vegetation of the created wetland is similar to that of the adjacent, natural wetland complex.

Offhand, I do not know of any plant species present in the natural wetland but absent in the created wetland. The created wetland is as vegetatively diverse as the natural wetland. Both are in an area hydrologically connected to the annual flood event of the Des Plaines River, which deposits fresh silt and plant propagules each year.

On nonindigenous species, carp appeared in the open water areas of the created wetlands about the second year and have caused a serious turbidity problem. No purple loosestrife has been observed to date.

■ **Question—Charlotte Reed:** Does Detroit have a different standard for mitigation? Is there a different standard when the applicant is a big steel company? We have a fill in Lake Michigan by a large inland steel company. The fill has been going on for years and years, and the company just got its permit renewed to fill 300 acres of open water of Lake Michigan. No mitigation, no public comment. Do you operate on different standards?

■ **Answer—Steve Eggers:** The 404 program is a national program. From one Corps district to another, we operate from the same regulations and policy—the memorandum of agreement on mitigation between the Corps and EPA. However, districts engineers, who make the permit decisions, have quite a bit of discretion.

■ **Question:** What is the average water depth in your two examples?

■ **Answer—Steve Eggers:** Water depths at the Wispark-Jerome Creek site include the entire gradient from saturated soils, to a few inches of standing water, to several feet of water. Water depths in the majority of the Wispark ponds south of the new highway are in the range of 4 to 6 or more feet. Water depths at the Patrick Lake bank site include a very broad outer fringe of saturated soils to 18 inches of water, to deeper water depths in the center of the basin, probably 2 to 4 feet as an average.

■ **Question:** What was the slope of the side margins in general on the first example?

■ **Answer—Steve Eggers:** On the Jerome Creek site, probably 15 to 20 to one. And after the corrective action on the excavated ponds, they were more like six to one—still too steep, but we really cannot correct it further.

■ **Question:** What is your perspective on the role of local government and local interest in long term maintenance of overseeing restoration mitigation areas?

In a local government situation, we have a Corps-driven mitigation effort to restore wetlands and floodplains in town, which has a conservation easement. Easement language will require perpetual maintenance and quality; an association of firms will own the land in the development area.

In some respects, we are like a puppy that just caught a rabbit. We have it, but we do not quite know what to do with it. We cannot seem to find help on finding the language for the conservation easement to cover maintenance and quality. The Corps seems to require that it simply must turn green, and in five years it is out of the picture. What do you see as the long-term local growth, and where can localities find help?

■ **Answer—Steve Eggers:** I think local governments could play an important role in doing things like designating primary environmental corridors and parkways. City ordinances can be designed for protecting wetlands and floodplains. I can send you an example of how to word a conservation easement. The Corps has been doing a lot of compensatory mitigation sites to require the permittee to unrestrict the site in perpetuity to maintain wetland wildlife.

■ **Comment—Daniel Willard:** The question on local government is fascinating—what works in one part of the United States will not work in another. In the Northeast, local town governments are quite powerful, very active, and energetic. They can pass either restrictive or other kinds of regulations within the right context. Moving west, the scale moves to counties and drainage boards. In the western United States, the federal government is the major landowner. The scale must be much larger—some 90 percent in federal land.

For example, the Lane County Council of Governments in Eugene, Oregon, has just done a watershed plan. Lane County is about the size of Connecticut. The plan has worked at that particular level; success depends on the traditional level of government in your area. Those must be coordinated over the watershed, which will have a different set of dimensions.

I recently came back from western New York where town governments—one upstream and one downstream—are practically armed at the border because of activities between them. The upstream government passed a regulation that harms the downstream government—in its eyes, at least. In the Washataw wetlands area in Michigan, a drainage board in one county made a decision that will impact Lake County downstream. County or local government involvement is crucial.

We cannot revise governmental patterns across the United States for ecological restoration. Instead, they must get organized and together. I do not know where that incentive comes from—maybe from citizens' groups, maybe a state governmental entity.

South Florida has water management districts that are larger than counties. Because they control the water supply valves, they are somewhat absolute monarchs with divine rights. The same is true of western water districts. Therefore, you must pick your unit of government to coordinate; but they must recognize the traditional patterns of local government as well. That is a tricky challenge.

For example, Cook County and the surrounding counties here have numerous units of government with many different goals. A unit large enough must coordinate those goals and still meet the needs of the groups in places like south Chicago. The role of local government is crucial, but it must fit the context of existing cultural systems and watershed structures.

■ **Comment—Dave Behm:** In our voluntary conservation easement program in Minnesota, the state acquires the easement. But in all cases, we require land owners—present and future—to be fully responsible for maintaining any practices put on the ground, including a restored wetland. With that caveat, if something were beyond the control of the land owner, the state would come back and help reestablish the practice as necessary.

Things also must be properly maintained. Up to this point, we have done an annual spot check of every state easement through soil and water conservation districts. We expect to reduce that to once every two years. ❑

# *PANEL: Development and Use of Technical Tools*

*PANEL: Development and Use of Technical Tools in Ecological Restoration*

# *Integrating Ecological and Engineering Design Elements*

Edwin Herricks
*University of Illinois*
*Urbana, Illinois*

Let me preface my presentation with a few remarks, including some thoughts that were sparked by comments made in earlier presentations at this conference. While several members of the audience were attending the Savannah Conference, I was attending an EPA workshop in Washington, D.C., that was focused on developing reliable condition-state indicators that could be used to monitor the effects of wet-weather, episodic events, particularly combined sewer overflows (CSO). The driving force for the focus on CSOs is recent congressional interest in modifying the Clean Water Act to include specific language requiring CSO controls. The cost of such a program would be \$150 to \$300 billion. To place that amount into context—since 1972 the United States has spent about \$60 billion on wastewater treatment.

The workshop participants were told that both Congress and the public are demanding a demonstration of effectiveness for money spent on control programs. The issue is not whether CSOs should be controlled to prevent local, national, or even global pollution; CSO control is an issue that must be examined to determine value for cash expended. We have heard a number of speakers talk of a global sensibility in restoration. We also must worry about a global "centsability"—a critical cash justification. When we consider the use of technical tools for restoration, we should recognize that restoration programs will be judged on the value produced for the cost incurred. This judgment of value will be based on a real, or perceived, assessment of restoration program success. Previous presentations, particularly Mary Kentula's, noted that the improper implementation of consciously developed and approved plans was a barrier to successful restoration. I will argue that this barrier to successful reclamation starts with poor integration of ecological realities in the engineering design.

## Integrating Ecology and Engineering

This presentation is about integrating ecological and engineering design elements in restoration projects. Although natural restoration is possible, and natural restoration elements are essential in most restoration programs, restoration projects often need some form of intervention to help these natural processes achieve a desired goal within a specified time frame. Restoration projects require someone to plan and execute them. That someone will need a concept that is translated into a design that will be translated into a specific restoration activity. In short, the technical tools for restoration must be successfully developed and used.

In this development and use of technical tools for restoration, a working connection between ecological theory and engineering practice must be in place. Successful restoration must know what to do and how to do it. Unfortunately a high degree of uncertainty exists in defining both what to do and how to do it.

If we do not know how to do something, we must at least have a method to identify a feasible or practical approach to the problem. In the past, the connection between ecological theory, which can provide an approach, and engineering practice, which provides the basis for implementation, has been less than direct. The ecologist has largely been responsible for specifying the ecological criteria that, hopefully, are translated into effective engineering designs. The engineer has had limited participation in this ecological criteria development and evaluation. From the other side, the engineer has been responsible for modifying existing engineering designs or practice to incorporate ecological criteria, often limiting the input ecologists make to the actual implementation process. In part, the lack of connection is based on poor communication between the ecologist and the engineer where different methods are used to deal with issues of uncertainty.

Often, the ecologist is excluded at the early stages of technical tool development when fundamental design changes could lead to a higher probability of success. This exclusion is often due to the ecologist's inability to specify exactly what is needed and an unwillingness or inability to grasp the difficulties of applying engineering to complex natural systems. Similarly, the engineer is often excluded from the early stages of criteria development where an understanding of the practical limits of any plan can be considered before an outcome is defined. This exclusion is often due to the perception that an engineer will limit the plan to a narrow set of options based on engineering practice and the misconception that, since the engineer simply "builds" what is specified, engineering issues need to be considered only at the final stages of project planning and implementation.

In fact, early involvement of engineers in restoration project design and ecologists in project implementation planning are necessary to assure project success at least cost. In this integration of ecology and engineering, two questions arise: What are the ecological criteria that, when specified, provide a set of objectives that allow for the interaction between ecologists and engineers? What can be done to assure that implementation plans are practical, meeting both ecological criteria and the limits imposed on engineering by the natural environment?

## The Ecosystem Context

A fundamental change in the way engineers and ecologists interact on critical environmental projects is needed. To produce ecologically relevant engineering designs, developing an ecological context for recovery and restoration projects is necessary. An appropriate place to start is by identifying ecosystem properties and processes that must be maintained to assure recovery. The terms "property" and "process" come from a National Research Council publication, *The Effects of Chemicals on Ecosystems*, published in 1981. The listing of properties and processes from that publication provided the basis to develop a list of ecosystem characteristics necessary to maintain an ecological system (Table 1). This table was developed at a workshop of ecologists and toxicologists on selecting the test systems most suited to identifying impact effects.

**Table 1.—Critical ecosystem characteristics needed to maintain ecological systems.**

To maintain a stable ecological system, that system must provide

- Habitat for desired diversity and reproduction of organisms
- Phenotypic and genotypic diversity among the organisms
- A robust food chain supporting the desired biota
- An adequate nutrient pool for desired organisms
- Adequate nutrient cycling to perpetuate the ecosystem
- Adequate energy flux for maintaining the trophic structure
- Feedback mechanisms for damping undesirable oscillations
- The capacity to temper toxic effects, including the capacity to decompose, transfer, chelate, or bind anthropogenic inputs to a degree that they are no longer toxic within the system

**Source:** *Herricks, E. E., and D. J. Schaeffer. 1987. Selection of Test Systems for Ecological Analysis. Water Sci. and Tech. 19(11):47-54*

This critical factors list includes many items we have heard about earlier. Habitat and a robust food chain are necessary for ecosystem maintenance. Phenotypic and genotypic diversity among organisms has been highlighted by several papers addressing biodiversity. Further, desired organisms need an adequate nutrient pool and a capacity to cycle nutrients and use available carbon effectively. Most importantly, feedback mechanisms that control undesirable oscillations in ecosystem structure or function are necessary. Control of extensive swings is related to the invasion or use of exotics or to a lack of consideration for the changes in a restoring ecosystem associated with natural successional processes. Finally, an ecosystem should have the capacity to temper or ameliorate anthropogenic stress. Natural ecosystems do have that capacity.

## Integrity Attributes

A second listing of ecosystem characteristics is provided by the National Research Council. A 1991 report on opportunities in applied environmental research and development lists critical ecosystem integrity attributes (Table 2). This listing, similar to Table 1, suggests the possibility of focusing attention on characteristics of ecosystems that are critical to their integrity.

**Table 2.—Critical ecosystem integrity attributes.**

- Elemental dynamics
- Energy dynamics (physical)
- Food web (trophic dynamics)
- Biodiversity
- Critical species
- Genetic diversity
- Dispersal and migration
- Natural disturbance
- Ecosystem development (successional processes)

**Source:** *National Research Council. 1991. Opportunities in Applied Environmental Research and Development. National Academy Press, Washington, D. C.*

These issues must be addressed in designing and implementing restoration projects: What guidance can we develop from the workshop and NRC compilations of critical ecosystem characteristics, and how can we recognize and translate measurements of these characteristics into criteria? How can we use these criteria to provide workable solutions that can be effectively implemented? Finally, when considering implementation, how do we meet multiple and sometimes competing criteria to achieve a stated objective?

## The First Challenge

The first challenge in integrating ecological relevance in engineering practice is to identify the most appropriate criteria to direct initial engineering design. Ecological relevance is often first developed by observing the environment, collecting data, and interpreting or assessing state or condition monitoring. How does this monitoring fit in project design? The answer lies in the unlikelihood that new designs will meet all, or even several, of the management objectives. Monitoring is needed to determine whether a design is appropriate for site specific conditions and to provide both the designer and engineer with a basis for assessing if initial criteria and implementation plans are appropriate. Monitoring will often show the way to identifying essentials. These essentials allow the ecologist and engineer to get a handle on a complex natural system and use that understanding to simplify design and implementation.

In reality, complex systems seldom allow for simple solutions; but simple solutions are clearly needed in most restoration projects. If a design does involve a simple solution, a firm foundation in theory or practice must support its use. This is where monitoring is needed again. Following selection of a simple system, effective monitoring requires information that will allow us to understand the consequences of our decision. We must recognize that monitoring-based evaluations are needed, in fact essential, to break down the barriers to successful restoration. As we understand more about a system, we can deal more effectively with its complexity; then effective implementation will be less of a barrier to success.

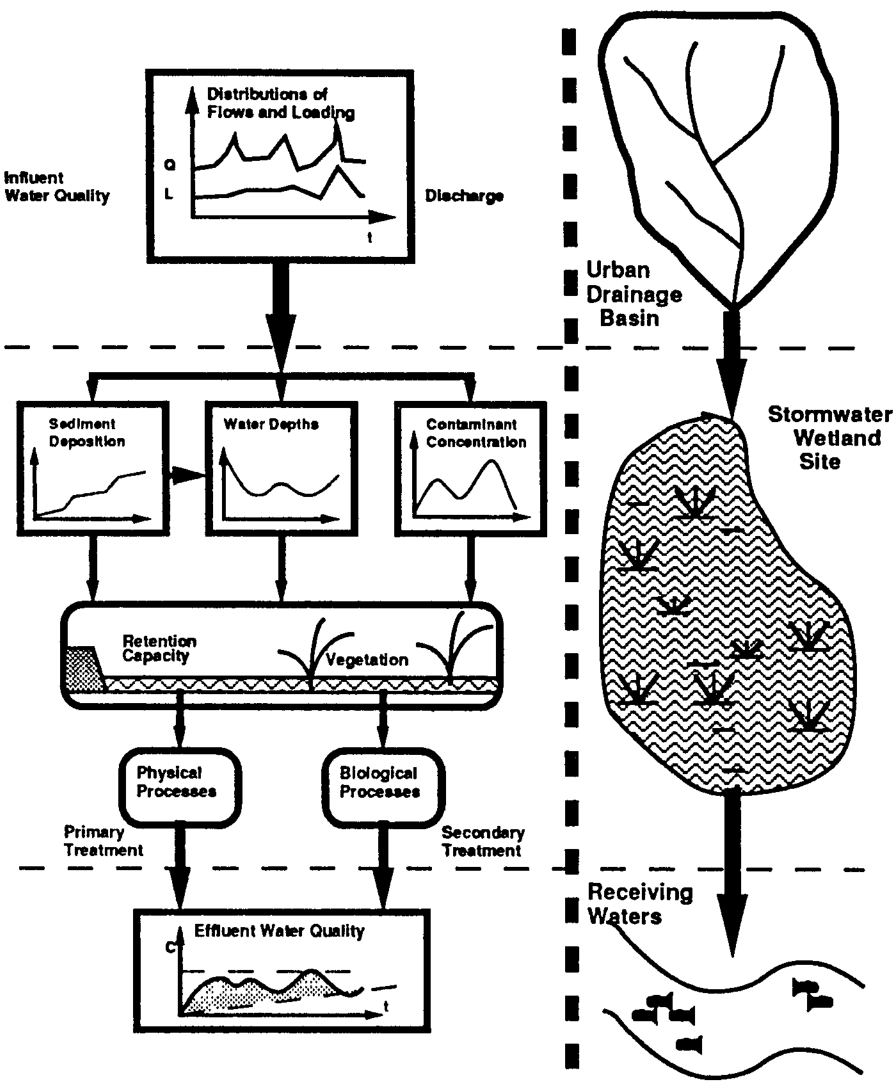
A final issue, one that we have seen on virtually every chart presented at this meeting, is that recovery is a time-based process. If we consider the identified integrity attributes in a recovery context, we must evaluate success or failure of a design through time.

To complete this discussion, we must address some simple implementation issues—space, opportunity, and stability. Implementing a recovery design requires a suitable colonization site. The site should have habitat and be of a sufficient size to accommodate all, or the desired, life history of desired species—*space*. Second, a ready source of organisms must provide the *opportunity* for ecosystem development. Nothing was more clear in the Minnesota wetland reclamation site than the demonstration that a readily available source of colonizing organisms led to rapid recovery. Finally, *stability* must exist to assure successful establishment of organisms, not simply colonization. This does not require absolutely stable situation, but stability developed in an ecological context. Generally, ecosystem stability is not maintenance of exact structure and function, but maintenance of similar structure and function, allowing for change within some limits defined by the system capacity (homeostasis).

## Stormwater Wetland Example

An example of the use of technical tools in recovery can be found in the design of stormwater wetlands. Many constructed wetlands are being designed to meet stormwater treatment requirements (Fig. 1). When designing a stormwater wetland, a typical goal is water quality improvement. A number of factors contribute to the capacity of this type of ecological system to meet water quality improvement targets. In reality,

**Figure 1.—Design context for stormwater wetlands.**




the function of these wetlands depends on both physical and biological processes to meet design criteria. The outcome of these designs can be reasonably predictable.

One of the simplest design parameters is basin shape. In an earlier presentation, we saw an Illinois wetland that had poor vegetation development because of basin configuration (steep sides and high average depth). Basin shape considerations should include the introduction of gentle banks, shoreline complexity, and general variability in basin topography (Fig. 2). A variable basin configuration will provide different habitat zones for different kinds of plants and associated organisms. Further, a natural hydroperiod—the time-related change in water depth—will change available habitat on some regular, or irregular, basis. How this variability is managed can be guided by ecological theory.

## Intermediate Disturbance Hypothesis

A valuable insight into maintenance of an ecosystem is provided by the intermediate disturbance hypothesis. This hypothesis suggests that to maintain maximum diversity in a system stress should not be avoided; in fact, stress is essential to system maintenance. The hypothesis is illustrated in Figure 3. At low and high levels of stress, ecosystem complexity/diversity is expected to be low. The highest complexity/diversity will occur at some intermediate stress level.

The intermediate disturbance hypothesis suggests that designs which produce constant conditions should be avoided. To direct design, basin configuration can be developed considering organism requirements. Usually, these requirements can be easily identified in a habitat response curve. Knowing the expected response of different organisms to physical conditions allows the

**Figure 2.—Habitat zones associated with water level change in wetland basins.**

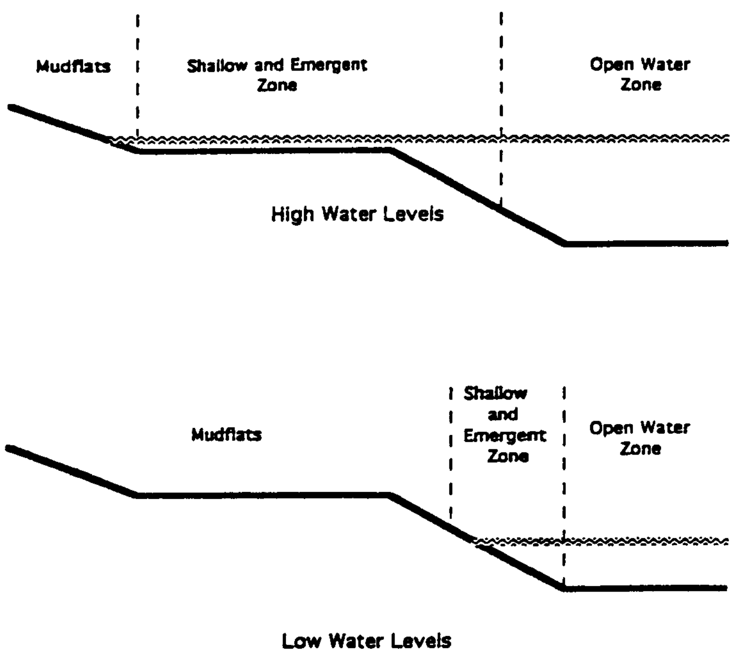
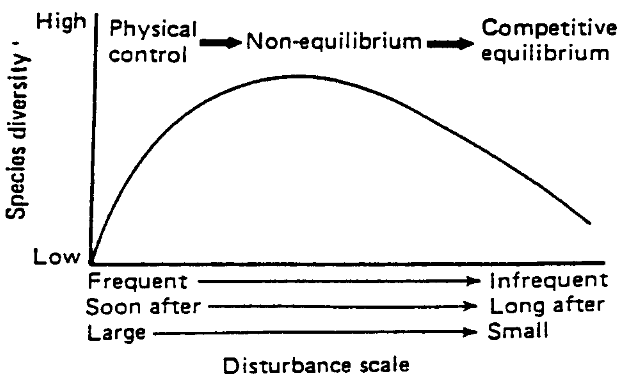



**Figure 3.—The intermediate disturbance hypothesis.**




designer to provide suitable depth conditions by adjusting basin topography. A topographic design can then be evaluated based on expected hydroperiod to select the configuration that provides an intermediate level of disturbance. An example of this type of design is provided in Figures 4 and 5. A knowledge of water depth requirements allows the assessment of area available for wetland plant species, developing habitat response curves (Fig. 4). We can also predict long-term trends in habitat availability (Fig. 5) where a control elevation, which establishes depth conditions in a wetland, is evaluated to determine the area available for plants requiring shallow conditions.

## Integrating Ecological and Engineering Design

The proposal that ecologists and engineers work together more effectively is not new. What may be new is calling for this interaction in a new watershed/ecosystem management paradigm. Ecologists should have the opportunity to contribute to the design of projects, to develop a "practice of ecology" that reflects the time scales required to judge success or failure. Unlike engineers who have a history of practice to depend upon, ecologists are at a disadvantage because they have none. Ecologists can, however, develop a successful ecological practice around restoration projects. What is needed is an analog to the long-term ecological research sites where long-term monitoring provides the basis to assess success or failure and to understand ecosystem recovery that will direct future reclamation efforts.

Engineers must be given the opportunity to contribute to ecological criteria development. They bring a practical and necessary perspective to the problem and, with the emphasis on cost and feasibility, a needed dimension to reclamation planning.

Clearly, ecologists and engineers need to work together to effectively address site-specific, as well as broader, watershed issues in restoration projects. Design and implementation must accommodate space and time in restoration and demonstrate success, not only for ecological integrity but also cost.

**Figure 4.—Habitat response curves for wetland plant species.**

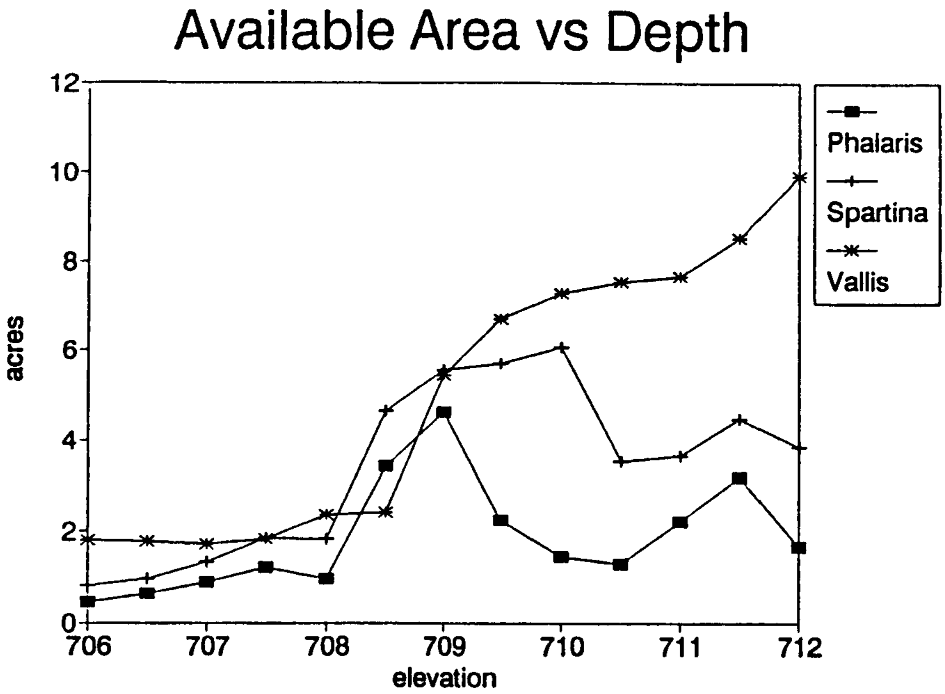
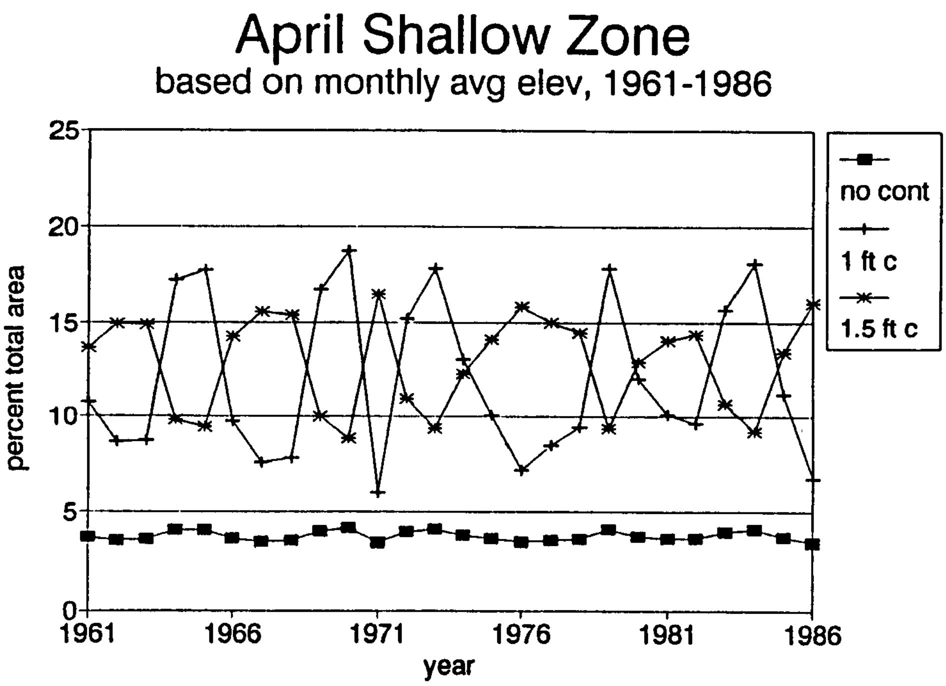



**Figure 5.—Predicted changes in the area available for shallow zone wetland plant species with different control height.**




## DISCUSSION

■ **Question:** In the profession of landscape architecture, an emerging subgroup—architects—have thought of many of these things. Is that your experience?

■ **Answer—Edwin Herricks:** Groups are effectively addressing these practical questions, recognizing that single disciplines cannot solve everything. Landscape architecture is an interdisciplinary activity that deals with many of these issues. Unfortunately, some landscape architects tend to be more design-oriented, from an aesthetic rather than an engineering design context. We need to improve this relationships.

■ **Comment:** In *Environmental Science and Technology*, the lead article is "Ecological engineering in the planetary life support system" with a good bibliography there. I was planning to have this copied.

■ **Comment:** Ecological engineering has a variety of definitions, but as in everything, we need to think about connections, which establish practical relationships. ❑

*PANEL: Development and Use of Technical Tools*

# *Stream Habitat Restoration Using Best Management Practices on Lower Boulder Creek, Colorado*

Jay Windell

*University of Colorado and Aquatic Wetland Consultants*
*Boulder, Colorado*

The state of Colorado covers about 104,000 square miles. The total water surface—ponds, lakes, reservoirs, and streams—encompasses 453 square miles, which is less than one-half of one percent of total land area. Colorado is a semi-arid desert, a very dry state.

The Boulder Watershed has three important features: the 119-square-mile Indian Peaks wilderness area beginning at the Continental Divide, the 234-square-mile Roosevelt Arapaho National Forest, and a 10-square-mile glacier which supplies Boulder's water.

Boulder Creek flows out of the canyon and down through the city. It has a new expanded and updated $21 million wastewater treatment plant—an outstanding facility (Fig. 1).

## An Abused System

The creek is severely channelized. In fact, from the mouth of the canyon down to its confluence with the Saint Vrain Creek, 71 percent of the stream channel has been channelized. The channel is 11 miles shorter than its historical length. Collectively, the problems relate to nonpoint source pollution including grazing and eroded banks. Almost 10 percent of our project reach, 8.5 miles, had severely eroded banks from grazing, gravel mining, and channelization, and contributed hundreds of tons of sediment yearly. In fact, we put in a stake and lost five feet of stream bank in one day. Irrigation return flows contributed thousands of tons of sediment each year. The riparian zone has been channelized, and buried in the sand. The trees have been cut for fire wood. It is an abused ecosystem in very ill health. Now, do you spend $21 million to put crystal clear water in this? I expressed my concerns to the engineers, who challenged me to find a solution.

This is how we got involved in the project. We created a very simplistic, cheap fish passage structure. Initially, the problem was point source pollution, mostly corrected by the new plant. In addition, we had a nonpoint source problem that precluded use attainment—in this case, Warm Water Class 1.

We wrote proposals and received funding. Phase I included an easement from Boulder Valley Farm—150 feet on each side of the stream bank—which we fenced (Fig. 2). We got another easement upstream. We received $350,000 for the first three phases. We are now in the process of doing phase IV, with a $225,000, 60/40 matching grant. We have implemented 12 different best management practices, divided into three groups: riparian habitat, aquatic habitat, and water quality habitat (Table 1).

We spent about $40,000 dollars for fencing. We excavated berms left over from channelization and planted them. We tried log revetment. It did not work very well. We tried jetties—they were not particularly cost effective. We have tried brush layering, wattling, and a boulder tow with brush bundles (Fig. 3). In beginning this project, we had good preproject/pre-treatment data. We conducted a use attainability study and have a year-and-a-half of water quality data. During the year, we looked at everything—fish, bugs, vegetation, and anything else we could think of.

**Figure 1.—The Boulder Creek Watershed was divided into an upper basin (mountain) and lower basin (plains) where 12 best management practices have been used.**

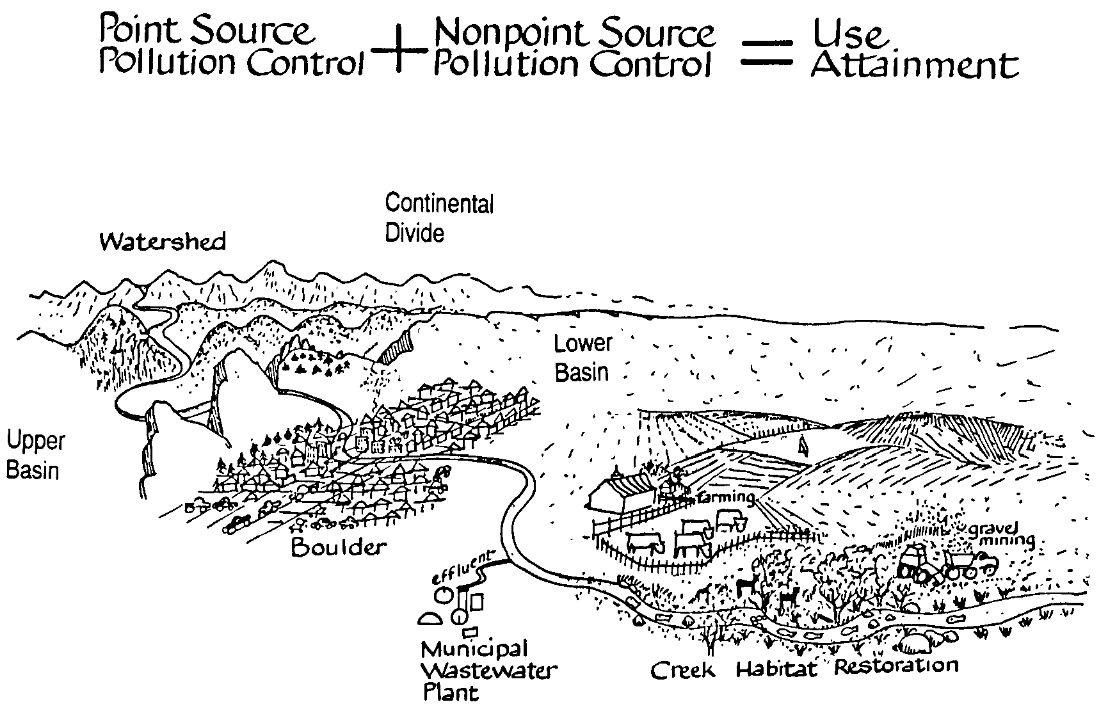
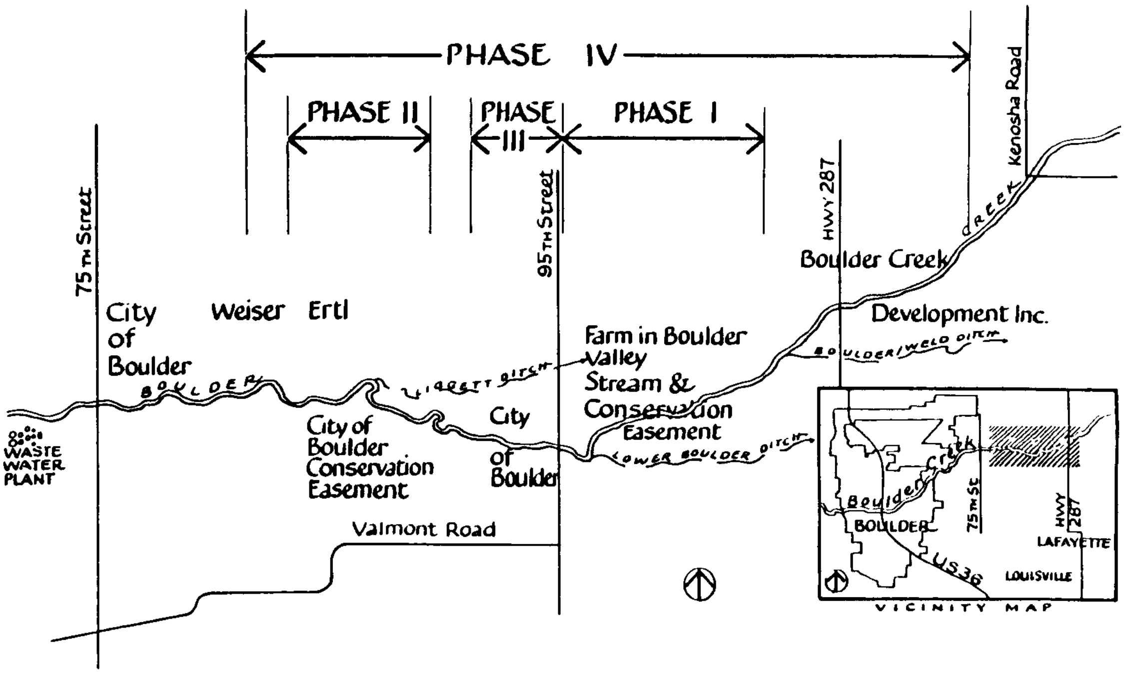



**Figure 2.—Land ownership and locations of the four phases of the Boulder Creek nonpoint source pollution demonstration project.**




Tremendous runoffs come out of the mountains starting the middle of May and going through July. In dealing with that situation, we cut the slope; but if you cut the slope off, you must haul it away. So, we have been using a balanced cut-and-fill technique with a boulder toe.

## Using Live Stakes

Brush layering techniques look good on paper. But in the field, construction is difficult. Brush layering involves using erosion control fabric. We also use a combination of brush layering and

**Table 1.—Groupings of the 12 implemented best management practices according to habitat type.**

| NONPOINT SOURCE | BMP |
|---|---|
| **RIPARIAN HABITAT** | |
| Overland flow | Fencing |
| | Vegetation planting/seeding |
| | Berm removal |
| Streambank erosion | Log revetment |
| | Jetties |
| | Brush layering |
| | Wattling |
| | Boulder toe/brush bundle |
| **AQUATIC HABITAT** | |
| Excessive width and shallow depth/aquatic weeds | Narrow channel with low flow pool/point bar/tailout |
| Flat water | Rock aeration structure |
| Diversion dams | Fish passage structure |
| **WATER QUALITY HABITAT** | |
| Irrigation ditch return flows | Wetland habitat enhancement |

wattling, using a fabric cover. In one case, we cut willows, tied them up, and planted them as bundles or live stakes. To grow, willows need to reach the groundwater table. The forest service and railroads gave permission to harvest the willows from railroads and irrigation ditches. After harvesting, we returned at the end of the growing season to measure new growth. From the stub next to the ground, the willows had grown 56 inches in five-and-half months.

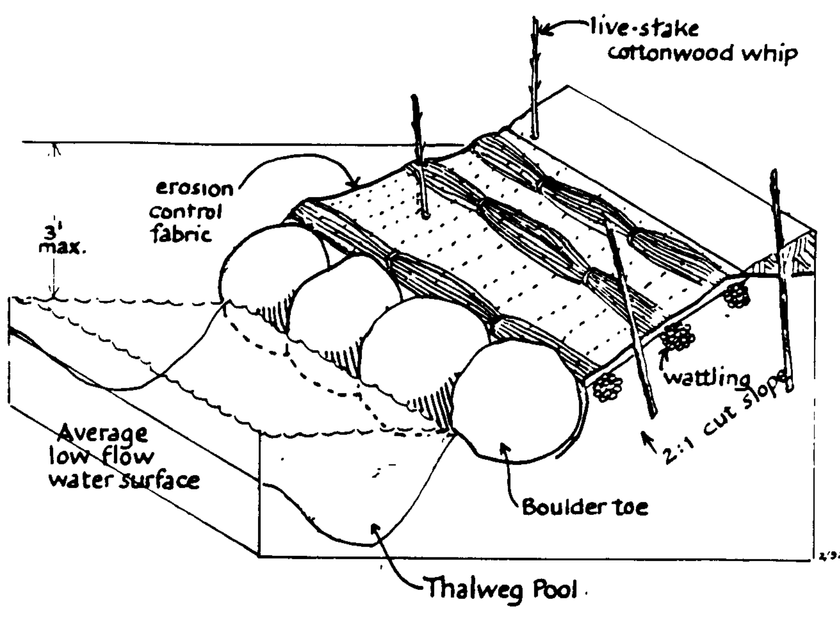
In one severely eroded streambank, the contractor put in a boulder tow and laid fabric. We tried several different fabrics. One fabric covered up the wattles and did not allow good growth. We also put in a low flow (thalweg) pool in a cut-and-haul streambank. The spoils removed from the pool were used to build a point bar, which is planted and left for normal successional takeover.

## Quality Control—a Problem

In a project for Coors Brewery in the city of Golden, we are creating trout habitat—a good example of technology transfer. However, quality control from the lowest bidder has been a serious problem. Contractors are responsible for constructing projects using nonstandard construction practices, but they do not know how.

Unless supervised every minute, they can destroy a stream in a hurry. The answer was to train the workers to do it correctly. This included putting in the boulder toe on the super-eroded

**Figure 3.—Wattling was one of several best management practices used to prevent streambank erosion.**



banks, laying in the willows extra thick, laying out the erosion control fabric, cutting down the bank to catch the edge of the erosion control fabric, and tying up the long bundles of wattles that were placed in a shallow trench and covered with fabric.

A big controversy occurred over whether to cut the willows after leafout and whether they would grow. While some say it will not work, it worked for us. Five weeks after we installed a wattle treatment with erosion control fabric, we had a giant storm. We lost a few willows, but the treatment held.

On the Jordan River in Utah, we used a boulder toe brush bundle technique to correct a highly eroded bank. This will come alive in the spring, and we expect it to withstand a runoff. The question of willow growth by the sand bar willow is important. In measuring several thousand, after 84 days the average height for the north and south banks was 15.2 inches. By the end of the growing season, the average shoot height from wattles covered with erosion control fabric was 27.4 inches (Table 2). The root structure was so dense that after five-and-half months we needed an ax and a hatchet to pull it apart.

## The Riprap Tragedy

Out West and in other places, riprap is common. This is a tragedy—the "riprap-ization" of America. These are not the kind of streambanks we want—people need to get back to vegetation. In Boulder and in Golden, we have grouted riprap—concrete walls—I call it "concrete-itis." The people who are paying and the people who are designing must never have heard of plants and roots. Nature has been stabilizing streambanks from the beginning of time with roots and vegetation. It is time we got back to roots and not use riprap.

## DISCUSSION

■ **Comment—Ed Herricks:** A major restoration in Illinois, the Court Creek project, uses willow shoots, and a number of devices have been developed to efficiently get these willow shoots into the stream banks to prevent erosion.

■ **Comment:** In working with the Corps of Engineers environmental and hydrologic lab at Waterways Experiment Station, we looked at four similar sites in different parts of the country. I certainly agree with the need for roots and vegetation. But using riprap conservatively as boulders to stabilize the slope toe and give the roots a chance to grow is a key factor in any vegetation project. You must control the toe in some manner. Right now, technology suggests that boulders or riprap, conservatively used, may be the best way to do it. Do you agree?

■ **Answer—Jay Windell:** Yes, your point is well taken. I want to get rid of the boulders and the boulder toe. We needed the boulder toe to get through this first runoff until that root structure developed. Then, if the boulders shift and move, they just create fish habitat. On concave banks, the vegetation provides overhead cover for fish. In monitoring fish populations, preliminary data suggests that they are coming back—they love the overhead cover.

■ **Question:** In the northeast quadrant of Colorado—the South Platte drainage—streams the size of Boulder cut off the colony-stimulating factor (CSF) there. From evaluating water quality parameters for dissolved oxygen, we found that in 30 percent of the streams temperature and unionized ammonia exceeded the limits. That would be directly related to the habitat conditions in those streams.

**Table 2.—End of season growth rate for the sand bar willow (*Salix exigua*) wattles planted on the north and south streambanks. Length of treatment for planting, completed May 1, 1992, was 170 feet and 225 feet respectively.**

| | | | | GROWTH | |
|---|---|---|---|---|---|
| ROW NUMBER | NO. OF 1m PLOTS | TOTAL NO. MEASURED PER ROW | MEAN NO. OF SHOOTS PER METER | MAXIMUM INDIVIDUAL HEIGHT (IN)[1] | MEAN HEIGHT (IN)[2] |
| North bank | 19 | 185 | 10 | 58.3 | 33.0 |
| South bank | 30 | 630 | 21 | 55.3 | 25.8 |
| North & south banks | 49 | 815 | 17 | 56.8 | 27.4 |

[1] Maximum growth for 178 days = 0.32 inches per day
[2] Mean growth for 178 days = 0.15 inches per day

■ **Answer—Jay Windell:** Yes, I did not mentioned that. The wastewater treatment plant has a $2 million nitrification tower, requiring $150,000 to $200,000 a year forever to treat total ammonia. When the total ammonia moves down the stream in the presence of high temperature and high pH, it is converted to un-ionized ammonia—and we still have problems. We spent $21 million and we still have an un-ionized ammonia problem.

So I have a very simple general biology hypothesis—narrow the stream and put it back the way it was historically. We tried to create pools on whatever concave banks were left and bury them in vegetation. Every place with shade has no aquatic vegetation. Channelization results in a wider channel with a thin film of water; 25 cubic feet per second comes out of the plant—day, night, and year around. This creates a biological jungle. As the plants photosynthesize, they pull the carbon dioxide out of the water, causing the pH to rise to 10. The lack of shade causes the water to heat up. Suddenly, the water has a high temperature, a high pH, and an un-ionized ammonia problem—particularly as the days start getting longer in the spring and shorter in the fall.

We are doing work on the un-ionized ammonia approach. We think we can bring the ecosystem back, and we think it is coming back. It is too soon to tell if we can solve the un-ionized ammonia problem—we have a long way to go.

■ **Question:** Did you use any species other than salix species in your work on the banks?

■ **Answer—Jay Windell:** Yes, a little bit—in fact, I have an additional sequence. Cottonwood poles develop an extensive root structure. Initially, we used the crack willow. Although its root structure grows incredibly fast, it is not a native species, so we were not allowed to use it. We used peach leaf willow, which no one knows anything about, and it has not done well.

■ **Question:** Did you find any significant differences in growth between fall and spring planting?

■ **Answer—Jay Windell:** I have not looked at that, but I will. ❑

PANEL: *Development and Use of Technical Tools*

# *Successional Restoration in Midwestern Grasslands*

Ed Collins

*McHenry County Conservation District*
*Ringwood, Illinois*

About 10 years ago, practitioners of restoration in both savannas and prairies in northeast Illinois had to face up to a pretty difficult fact—that savanna and prairie restorations undertaken across the region were stalled in an early phase. A few common forbs and tall grasses, like big bluestem and Indian grass, lack the richness and diversity typical of remaining high quality natural areas.

## Savanna Projects Encouraging

So quite independent of one another, several projects began to experiment with different methods for establishing prairie and savanna restorations. The results are not quantitative; much is narrative and based on the observations of individual field practitioners. But the initial results have encouraged further study among the scientific restoration community.

Traditional approaches to restoring grasslands in the Midwest have focused on restoring native species to formerly plowed ground. The process was pretty much the same whether the ground was not plowed, was pastured, or was a hay field—plow it first.

For about 15 or 20 years, this has been our method to restore prairies in the Midwest, primarily on former agricultural ground and directly into soil that had row crops the previous year. For the most part, the results have been disappointing—large stands of ranked grasses, with a few forbs like the Indian grass, represent a real lack of diversity in the overall community.

In particular, spring flowering plants are absent, and traditionally conservative species that only appear in the West, like prairie clover, are the highest quality remnant. Trying to add more forbs to the initial mix has helped somewhat, but the overall results have been the same—a real lack of diversity across the board.

Drawing and introducing transplants of more conservative species have generally failed. Although in isolated cases it has enriched particular flux, it is not cost effective and is very labor intensive.

Why doesn't it work? We can develop a native hay field or a very poor quality prairie using these techniques, but we cannot replicate high quality areas. The reasons are several. Agricultural land in general has often been abused; sometimes the land contains chemical carryovers from previously used fertilizers, pesticides, and herbicides. This is a very hostile environment. When introducing seeds into an area with primary succession, the environment is not suitable for many of the more conservative prairie and savanna species. With poor soil structure, the area harbors intense competition and high disturbance, resulting in species that can handle a disturbance regime. This is a selective pressure for species like ranked grasses or aggressive forbs.

Similar situations exist in savannas. At least in the Midwest, the 90 percent that remain have no existing herbaceous cover and have no resemblance to presettlement time. In a typical midwestern and especially northeastern Illinois savanna, the remaining oaks are overgrown with a brush layer of exotic or introduced species.

The first process of structural restoration is to get rid of the brush layer and open up the savanna. This highly disturbed area creates the same type of situation for introducing a herbaceous layer, often resulting in something that remotely resembles what we believe existed in the savanna's herbaceous layer prior to settlement. Species that make their home somewhere in Eurasia often come up after structural restoration is complete and the savanna restored.

## Natural Succession

In developing several projects, we began looking at different approaches to get a better mix of species for a natural succession restoration. Our goal was to use the process of succession to get a more complete and diverse mix of natural species.

In pastureland, the process works in two ways. Where existing cover composed of old pasture grasses or hay is in place, the process involves direct sowing. This was used on a small scale in the North Branch Prairie project along the Chicago River by sowing a matrix of Kentucky bluegrass, redtop, and some European brown. After a fire with some cover remaining, seeds were sown into the ground and raked directly into a Eurasian mix. The former process would have been to plow this up, get rid of it in some way, and start from scratch.

The same agricultural technique can be used on larger sites with a conventional seed drill adapted for no-till planting. A machine with cutters slices through the sod and lays down the seed on the existing matrix.

Correcting other damage to the site improves the process. In our part of the country, this involves restoring the hydrology. Upper midwest and northeastern Illinois has a poorly drained landscape from excessive tiling and ditching. In fact, in the 1930s, the federal government estimated that Illinois alone had enough underground tile to encircle the world six times and enough above-ground drainage ditches to stretch in a straight line from Chicago to Outer Mongolia.

## Proper Management

Once the successional restoration has been sown, proper management is critical to success. This can involve several approaches. Traditionally, burning has been used; but experiments show that mowing will do the same thing. Mowing suppresses the Eurasian pasture grasses and, when done at a high enough level—about four to five inches—it does not harm the developing native species. After three or four years of mowing, the system is much more diverse. The Eurasian species decline and the native ones surge.

While we do not have a lot of quantitative information, experiments underway now should yield some future results. A control plot on the North Branch Prairie project consists of Kentucky bluegrass and introduced Eurasian redtop. When we isolated the control plot, we started a second plot composed of drop seed and Indian grass, two native prairie species sown directly into the same matrix.

Another plot done at the same time has forbs typical in a prairie region such as rattlesnake master, clover, and the more common black-eyed Susan. These have come up through the matrix. The European grasses are becoming more and more difficult to find. In fact, after 10 years, the Eurasian grasses have disappeared completely and been replaced by native species. In another plot, some conservative species such as prairie dock, spiderwort, blueflower, and other conservative grasses dropped seed.

## Only Islands Exist

We are not exactly sure why this works—we just know that it does. Those involved in successional restoration have some ideas. In the Midwest, we are not dealing with a landscape anywhere close to its condition at the time of settlement. In fact, only about 0.07 percent of Illinois is in its original condition; the rest has been highly modified. Where once wide expansive prairies were filled with conservative species, only small isolated islands exist.

Fragmentation and plowing have eliminated many of the most common species. This complete reversal means that species on the original prairie, now considered conservative, are far more common than those typically found in disturbed relics or in prairie restorations. Those more tolerant of disturbance or of harsh soil conditions are most common.

A more developed soil structure and many varieties in the soil may be necessary to develop the more conservative species. A nonaggressive Eurasian grass can be sown into a plowed field waiting for restoration to begin or by using old pastures and former hay fields as initial restoration sites. This allows the soil to recover somewhat from row cropping, develop a more advanced soil structure and profile, and at least at the fungal layer, recover somewhat from farming effects. This could be one reason why this process is so successful.

For extremely small-seeded species like the shooting star, an existing matrix may prevent frost heave. Experiments on a number of sites show that these species typically put out little vegetative growth the first year; they typically heave out of the ground during hard winters. Sowing these species into an existing matrix that can hold the soil provides a much better chance at survival; therefore, the establishment rate is much higher.

The same process is used in a savanna, but we need more basic research on this technique. Experiments and narrative evidence gathered in northeastern Illinois suggest that this process might eventually replace more typical approaches to regional prairie and savanna restoration. Specifically, brush is cleared and bare soil seeded down with Eurasian pasture grass and redtop, tolerant of shade. Several years later, savanna and prairie species are introduced. The result is a structure and diversity more typical of natural area remnants.

## DISCUSSION

■ **Question:** At the time of settlement, farmers sometimes burned their prairies to establish Eurasian grasses. That sounds like reversing the process. Any comments?

■ **Answer—Ed Collins:** That is a good point. West of the Mississippi where the native prairie has a much longer tradition than in Illinois, the timing of the taking of the hay crop largely determines whether a field or a prairie evolves toward a cool-season Eurasian grass mixture or retains a native warm-season prairie grass mixture. Fields planted to hay over time loose their diversity and move toward cool-season grasses. Thus, the process works both ways and is greatly dependent on both the initial sowing and management techniques employed afterwards.

■ **Question:** I am aware of an Illinois Beach State Park effort to map oak savannas according to their relative quality. Does McHenry County have a similar oak savanna program?

■ **Answer—Ed Collins:** Most counties in the region have made efforts to map the location of old savannas. They are fairly easy to find through soils and air photos. In our part of the world, they are the favorite place for putting houses and survive for a number of reasons. People originally built houses there, used the growth for timber, and used the land for grazing. So the savanna was not destroyed as completely as the tall grass prairie. McHenry, Kane, and Lake counties have a process underway to locate them.

■ **Question:** I have been involved in similar efforts in Missouri. Were you able to adequately control the existing vegetation by using fire and mowing, without using chemicals, when you were no-tilling into sod?

■ **Answer—Ed Collins:** Yes, we were. I initially thought that we would not be successful. Some European grasses are very aggressive, particularly smooth bream. We did exactly what I explained—no-till seeding into a burned smooth bream field. Within five years, the bream had dissipated and prairie grasses had taken over. So we have not needed chemical control in the field.

A lot depends on the field's productivity. A hay field past its prime—seven to 10 years old—may already be declining. Holes may have opened, allowing in goldenrod, milkweed, or some other old field successional plants. This is when these fields are ripe for successional restoration. Currently, we have not experimented with alfalfa, although we plan to try experiments this year.

■ **Question:** You mentioned a burn that occurred with bream. What was involved?

■ **Answer—Ed Collins:** The field was burned three times in five years and always in the spring.

■ **Comment:** In Missouri, we had trouble with fescue, which is very competitive, and somewhat with blue grass; the bream was easier.

■ **Comment: Ed Collins:** For cool-season Eurasian grasses, a late spring burn used in sequence with successional planting for several years will suppress the European grasses in their early growth when they are most susceptible. This will tip the balance in favor of warm-season grasses. That technique, used in association with successional restoration, is productive. ❑

*PANEL: Development and Use of Technical Tools*

# *Restoration of Riverine Habitat Diversity on the North Shore of Lake Superior*

**Ed Iwachewski**
*Environment Canada and*
*Ontario Ministry of Natural Resources*
*Thunder Bay, Ontario*

I have been fortunate to work on Lake Superior's north shore, renowned for its physical beauty. In most locations, you can find magnificent scenery without much difficulty and without worrying about seeing a railway, a truck, or people. Over the past 100 years or so, some areas have changed dramatically. The world record speckled trout (14 pounds) was caught in 1916. Back then, people paid $24 for a two-day license to fish the Nipigon River—people in Ontario now complain about a $15 license to fish for the whole year. At Thunder Bay, extensive wetlands once lined the entire waterfront.

All around the Great Lakes, extensive degradation of water quality and habitat has resulted in 43 locations designated as requiring Remedial Action Plans (RAPs). The four Areas of Concern on Lake Superior's north shore are Thunder Bay on the west, Nipigon Bay, Jackfish Bay, and Peninsula Harbor. I will focus on Thunder Bay and Nipigon Bay.

## Stresses Abound

A variety of stresses plague the Areas of Concern including effluent from pulp and paper mills, which is one problem common to all four areas.Thunder Bay is famous for shipping, and recently handled the second largest amount of tonnage of any Canadian port. It was once called "the Chicago of the North." Extensive dredging and filling from shipping-related development and the creation of road and railway linkages has greatly altered the waterfront. The industrial growth has caused a loss of aquatic species diversity and abundance, degraded water quality, and eliminated most of the original wetlands.

North America's recent economic recession has been hard on everyone. The dramatic downturn in industrial activity left many plants closed or abandoned. While this was not a desirable event, it created a chance to work on some of our degraded areas.Environment Canada recognized this window of opportunity and created the Great Lakes Cleanup Fund. The fund provides seed funding for partnerships to undertake water quality and habitat restoration initiatives on the Great Lakes, specifically within Canadian Areas of Concern.

The community of Thunder Bay numbers about 130,00 people; many are currently unemployed. A number of sites were selected by our Public Advisory Committee through the Remedial Action Plan for rehabilitative work. Coincidentally, the sites that need restoration were also those chosen by agencies. We believed we could have greater positive impact by focusing on the mouths of tributaries. In order to avoid spreading ourselves thin, we developed projects people could see—improving or replacing spawning habitat, working on wetlands and littoral zones, and increasing recreational opportunities to bring people back to the waterfront.

One project was to create a fish ladder on the Current River. A dam has been in place since about 1910 and has blocked the migration of a variety of salmonids to prime habitat upstream. In partnership with the North Shore Steelhead Association, the provincial government, and the federal government, we built a fish ladder and a series of step pools for operation this spring. The Current River's mouth has three new spawning areas, replacing areas dredged out in the past. Through mark and recapture, we determined that over 1,000 walleye spawned here two years in a row.

## Assessment, An Important Element

A most important element in our project is assessment. We have three years of preassessment data on each project site and a commitment for at least three years of post assessment. We hope to establish other partnerships for additional long-term monitoring.

A former walleye spawning bed at the mouth of McVicar Creek had been degraded by construction of an overpass and railways. Silt covered the entire bottom, which was devoid of rocks and vegetation. Engineers did flow modeling, resulting in excavating and rebuilding the spawning bed. Bank stabilization ensures that no new silt degrades the bed. Currently, we are building a 175-meter crescent-shaped island to shelter a new wetland and provide nursery and spawning habitat to increase the diversity of the creek mouth area.

The Neebing MacIntyre Floodway is designed only to carry flood waters. It was built in 1980, without any thought to fish habitat, filling in the lower stretches of two natural rivers and excavating a new flood channel. During premonitoring, the only location where we found any type of crayfish, for example, was in the chassis of a Motorola Quasar color TV trawled out of the bottom.

Convincing engineers who had designed and were responsible for maintaining the flood channel to allow any work was difficult. We were not allowed to do anything to alter the channel or its capacity to carry flood waters. We could only work within five meters of the channel on floodway property.

These restrictions constrained our choice of designs, resulting in simple structural designs to add diversity, structure, and cover along the shore. We were finally allowed to build 20-meter-long embayments. If these proved successful, we hoped we could add these or similar structures along the entire length of the floodway to improve diversity and habitat.

In summer and fall of 1992, the catch of fish from electrofishing and seining surveys in a 20-meter embayment was higher than in the 400-meter control stretches or in any other portion of the floodway. This successfully demonstrated, at least in the short term, that these structures benefit the floodway.

In the Kaministiquia River, concrete or steel sheet piling lines most of the shoreline. In an effort to provide public access to the water, the city built the Donald Street Underpass, a small pavilion out on the water. The engineers, however, insisted on using sheet piling, resulting in a vertical face and dredging to 28 feet deep.

## A Hiding Place for Bass

Since the channel could not be altered, we convinced the engineers to design at least some overhang on the concrete, similar to a natural undercut bank. However, the concrete allowed for no vegetation on top. In addition, we had them weld the steel sheet piling on the vertical face or shelves to provide cover and hiding spots for bass. The 8-foot sections with shelves along the sheet piling would allow a contrast with the nonshelved sections. Last summer divers observed that bass, in fact, were hiding in the shelves. Unfortunately, the water was too turbid to quantify the degree of use, so we do not know whether or not this method is a success.

This was an approach to allow some new thinking and it has paid off. In designing the next 200-meter stretch upstream, the engineers decided to go with more sheet piling, drew some shelves on and hoped this would make the biologists happy. While this was nice, we could have had more input earlier in the design. In fact, our new design will maintain a section of soft shoreline for vegetation and create a naturally overhanging bank. Instead of putting the pedestrian walkway on sheet piling and backfilling everything, placement on posts will allow for natural water flows. By reducing costs from $900,000 to $450,000, the city was happy and accepted our design.

The McKellar River is a heavily armored channel designed for navigation, with paper mills upstream. A covered landfill site is located where the river enters Thunder Bay Harbor. Many believe it is a natural meadow. This summer we hope to create two lagoons to provide spawning habitat for bass, perch, pike, and waterfowl nesting. In addition, we are planning a series of handicapped-accessible fishing platforms and walkways. The city, provincial, and federal governments are contributing funding to this project.

## Walleye Absent

The town of Nipigon has a beautiful setting, but changes to the area have been significant. Log drives and the construction of three hydroelectric dams on the Nipigon River degraded riverine habitat and blocked migration routes for fish. Water quality in Nipigon Bay was affected by the pulp and paper mill in the nearby community of Red Rock, although recent improvements have been made. Our goals here are to rebuild the historic walleye population, restore degraded wetlands and spawning sites, and develop a water management plan for the river.

Nipigon Bay once produced some 50,000 walleye each year. After four years of netting found no walleye in the system, we began an extensive adult walleye introduction program. We have stocked three genetic strains and over 14,000 adult pickerel. Through genetic mitochondrial DNA markers, we can determine the most successful strain in rebuilding the population. We also restored some spawning beds along the river.

The water level management plan is likely our most important project. Ontario Hydro has three hydroelectric generating stations on the Nipigon River. In the lowest one closest to Lake Superior, fish of all types move up to the base of the structure and spawn. Chinook and coho salmon, steelhead and brook trout, and walleye all move into this area to spawn.

However, when the plants are not generating power, they tend to hold back water. As a result, the eggs become dewatered, and in the winter they freeze and die; even the young fry become stranded in pools, freeze, and die. To prevent this, we are working on a long-term plan that will take about two years to develop. It must be a cooperative venture with Ontario Hydro and all the system's users.

## A Friendly System

The township of Red Rock, with its paper mill production and its employment base cut in half, wanted to build a marina. We started with a standard L-shaped rock breakwall design used in Canadian harbors. We modified it, adding fish habitat and cover along the inside and outside of the breakwall, pedestrian walkways, and fishing platforms. The system is both people and habitat friendly.

The rock breakwall brings a net productive benefit to the habitat, especially with an all-silt bottom. A report, produced about two years ago, showed that rock breakwalls do have fish in an aggregating, if not productive, capacity. Eventually structures with overhanging logs, undercut banks, and other elements will look natural. In addition, we can improve the productive capacity, producing a model for all breakwall designs. At the end of construction, we hope to produce a manual on breakwall habitat-friendly construction.

## Partners are Vital

Having partners is vital. Partners enabled us to get funding through Environment Canada, which can only provide one-third of the funds. The lack of funds can cause an individual, agency, or group to place a project low on the priority scale. But with partners, projects move up on the scale, and people are more willing to become sharing partners.

The public is very important. We have strong community support in Thunder Bay, and we never miss an opportunity meet the community—at a boat show or in setting up our own displays. The environmental assessment process and public input phase for each project is important. Environmental assessments are tremendous public interest generating and support devices, even though agency staff are often afraid of them.

Now we are working on public support for other programs, like the Bi-National Program to turn Lake Superior into a model for zero discharge of persistent toxic chemicals. Our Lake Superior Program Office is also involved in the RAP initiative. Those projects stress the need to look at all aspects of improving habitat and water quality together, not just one project or idea. You must have an ecosystem approach.

Industry is a major partner. Without industry, our towns would not exist, especially on the north shore with its many one-industry pulp and paper mill towns. Without industry's cooperation and involvement, the towns would shut down. But we cannot make demands—support must be a cooperative effort—and it is not an easy process. Industry acknowledges the controlling regulations, but some realize that partnerships and funding will enable industry to save money—by doing now what would have to be done in the long-term.

## Enhancing Productivity

Our relatively maintenance-free cleanup projects should enhance productive fish habitat and create long-term benefits. We also expect partnerships to be long-term and begin a new approach. Our community has a heightened awareness about environmental matters. In these tough economic times, people must maintain the impetus and the desire to embrace environmentally friendly projects. We may need to make some economic tradeoffs; we may also need to bite the bullet. But we must think about the long-term benefits. After all, the real reason to take action is not only for ourselves, but for the future.

## DISCUSSION

■ **Question:** How are you dealing with contaminated sediments in your restoration plans?

■ **Answer—Ed Iwachewski:** A number of areas within Thunder Bay Harbor, Nipigon, and Peninsula Harbor have contaminated sediments. We have been working on a variety of projects there. The worst problem is a Northern Wood

Preservers' creosote blob. We have a number of ideas about how to clean it up.

A benefit with the Cleanup Fund is that it is not confined to the north shore of Lake Superior; it is in all 17 Areas of Concern on the Canadian side. A number of demonstration projects—in Hamilton and Toronto harbors—work on things like in situ bio-remediation, techniques for removing sediments, catalytic action to destroy contaminants, and replacing the sediments. We have not actually done any contaminated sediment work yet; we are hoping to gain from the other cleanup projects through technology transfer.

In Peninsula Harbor, which has mercury contaminated sediments, we are working on a process involving selenium to influence or interrupt the methylation of mercury at the water sediment interface. We hope to set up a pilot scale version next year.

■ **Question:** Any estimate of when you would actually start remediation in Thunder Bay or Nipigon?

■ **Answer—Ed Iwachewski:** We hope to deal with the creosote problem in Thunder Bay this year. The committee is moving from a litigious to a cooperative stance and is debating which of six technologies to use. The technologies come with cost tradeoffs—some are cheaper than others. I do not know which would be the most effective technology.

■ **Question:** Single, extractive industries plague many small communities around Lake Superior basin. We want to help those communities move forward into a less extractive economy or some alternative system to meet social needs. Does Ontario have any formal economic restructuring program available to communities like Red Rock or incentive ideas on converting industry into chlorine alternative bleaching or other types of development?

■ **Answer—Ed Iwachewski:** While not a formal plan, when a mill shuts down restructuring happens quickly. The Ministry of Industry, Trade, and Technology may have a strategy. But in the four north shore communities, we have not seen any serious attempt to find alternative employment. All four communities are in timber harvesting and pulp and paper production. They all are trying to shift their economies to tourism, but that will not replace the jobs that pay $16 or $17 an hour.

■ **Question:** Have discussions taken place with the Ministry of Industry, Trade, and Technology about retraining workers and gearing retraining toward ecosystem restoration or other habitat, labor-specific tasks to improve the area?

■ **Answer—Ed Iwachewski:** That is a great idea and I would like to see it happen, but I do not believe it has ever been broached with the proper people. The breakwall structure in Red Rock is a small example of a community-based project. The project required the contractor to use local labor and sources. The marina itself will have 238 slips using floating docks. We hope to set up our prefabrication structure, hire local people, buy wood and materials, and have the people assemble the docks. But that is small scale for one summer.

■ **Question:** The United States has had good relationships between EPA and the tribes. The indigenous people along the southern shore will be included in future policy discussions about Lake Superior's management. What is Ontario doing to work with native people on the northern shore? Are they included in management prescriptions or in planning out what designated uses the waterways will support?

■ **Answer—Ed Iwachewski:** Yes, but those discussions are in their infancy. In Canada, the Supreme Court has not decided on treaty rights. Similar to the United States, Canada has a variety of treaty rights—different treaties were signed at various times with different bands. On Lake Superior's north shore in the Superior Robinson treaty area, most economic development efforts have been related to the forest industry and commercial fishing. ❑

# PANEL: Development and Use of Technical Tools

# General Panel Discussion


Edwin Herricks
*University of Illinois*
*Urbana, Illinois*

Ed Iwachewski
*Ministry of Natural Resources*
*Environment Canada*
*Thunder Bay, Ontario*

Jay Windell
*University of Colorado and Aquatic Wetland Consultants*
*Boulder, Colorado*

Ed Collins
*McHenry County Conservation District*
*Ringwood, Illinois*


**Comment—Ed Herricks:** The conference organizers have prepared several questions for the panelists to consider. Two questions are somewhat related: What are the technical capabilities needed to do restoration in particular ecosystem types—forest, wetlands, streams, and others? And what are the technical needs? This is a uniquely qualified group to talk about that technical capability.

■ **Comment—Jay Windell:** We have used some 1,143 feet of wattling, 1,338 feet of brush layering, and not near that much boulder toe brush bundles. I have seen projects around the west that have used either no vegetation or sparse vegetation. You cannot use too much. It is essentially free, except for the labor; and we have hired people for $6 to $8 an hour.

A major concern regarding capability in stream restoration is that when you start fiddling around with the banks, putting in point bars and concave banks, the additions are not where Mother Nature really wants them. Then, you are setting up for disaster. We need to understand the real factors that may be controlling what is happening in the watershed. One area in which we have a lot of information and that is used inadequately is hydraulics.

Let me tell you a sad story. In phase one, I designed 11 low flow pools within a highly channelized 1.3 mile reach. Seven of them filled with sediment the first year. The five left are on the concave bank, right where Mother Nature would have put them. I cannot believe I made that mistake. In fact, I did that purposely because I wanted to restore some of the historic meandering. The land owner was amenable to that.

■ **Comment:** In considering restoration, one thing we should keep in mind is how the ecosystem will work. Starting with a bare plot of land will be difficult. To succeed, you need to take a running start from some system components and build on your knowledge of what the system was like. Then do whatever is necessary to restore the system.

■ **Comment:** That is absolutely right. We are looking at restoration out of the project phase now and faced with ecosystem problems on the landscape level. The North American system needs to be built at a large scale. To accomplish this, we need to further the marriage between engineering and ecology. We need to expand it to include marriages between the ecologists and restorationists and other practitioners—farmers, people who clear land for a living, developers—familiar with technologies that may need adapting.

Beyond that, we need to develop ways to work with a large portion of the system at one time. Successional restoration offers possibilities to do that on a large scale on land currently used for public grazing, for example. Out west, vast tracks that are degraded through over grazing could be brought back by the same process. Both that marriage and technology between different disciplines and upscaling as much as possible is important.

■ **Question—Ed Herricks:** What is the status and usefulness of prediction modeling? Maybe Ed Iwachewski can provide some insight since he was in a situation requiring negotiations with engineers over a channel requiring a certain flood flow. These engineers obviously provided significant input into the decisionmaking to provide the necessary flows to prevent flooding. Do you have any comments on how their modeling, or your modeling, fit?

■ **Answer—Ed Iwachewski:** A biologist gets lost when engineers start arguing over models. For example, in Ontario stream flows, engineers are using what is called the Hec II model. They need to explain what they are doing in terms that we can understand and that integrate ecology and engineering. In designing our island, we successfully brought in a hydraulic specialist; an engineer determined how our sedimentation patterns would fall out to prove to the harbor commission that the island would have no negative impact on navigable channels. On the downside, engineers also did predictible modeling. They figured out that type of structure would withstand flood flows but would require sheet piling, log cribbing, and other unnatural looking structures that we wanted to get away from.

An important thing that we fail to do is publish materials done through a variety of jurisdictions. The more you get involved in habitat restoration, the more you realize that any innovative ideas you have probably have been done before. I wish we could all submit articles to a journal of failures. Whether the failure is engineering or improper ecological or biological design, people need to know that someone tried and it did not work. Maybe you can modify it in some way to improve it. Of course, people are often hesitant to announce their failures. But that is one of the critical issues of engineering practices—to study failures and pass them on in practice.

■ **Comment:** You are referring to engineers and consulting engineers in considering channel morphology and other activities, but you have overlooked an entire academic field within the discipline of geology—fluvial morphology. These individuals have been studying this for years and published many articles in this area. I encourage you to check those. ❑

# *PANEL: Measuring Success*

*PANEL: Measuring Success*

# *Establishing Quantitative Performance Criteria for Wetland Restoration*

Mary E. Kentula
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*Environmental Research Laboratory*
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A new publication from EPA Wetland Research Program is called *An Approach to Improving Decision Making in Wetland Restoration and Creation.* The book is a synthesis of five years of research done under the program. In addition to the research conducted by the authors, EPA funded studies across the United States that contributed to the work.

The book has several chapters, with each of them taking an aspect of the approach and developing it. Fundamentally, the theme is to use existing information—projects in place as experiments in progress—to guide future decisionmaking.

## Developing Performance Criteria

The evaluation of data can be used to develop performance criteria and improve design guidelines. The following examples are applicable to systems like a pond with a fringe of freshwater marsh.

The evaluation revolves around what we call the "performance curve." This involves looking at projects relative to natural wetlands. The curve's importance is in documenting if the level of function comes back and how long it takes. Using this same technique, Dennis King has taken these principles and related similar data to how to justify requiring certain mitigation options and how to evaluate—for example, different design approaches and the expense relative to expectations from the project (see Fig. 1).

One of the unusual things about our approach is that means are generated with error bars. The status report on creation and restoration showed that a lot of case studies are out there, but we have no idea of what is happening in general. Estimates of the variability in projects will help to describe the general status.

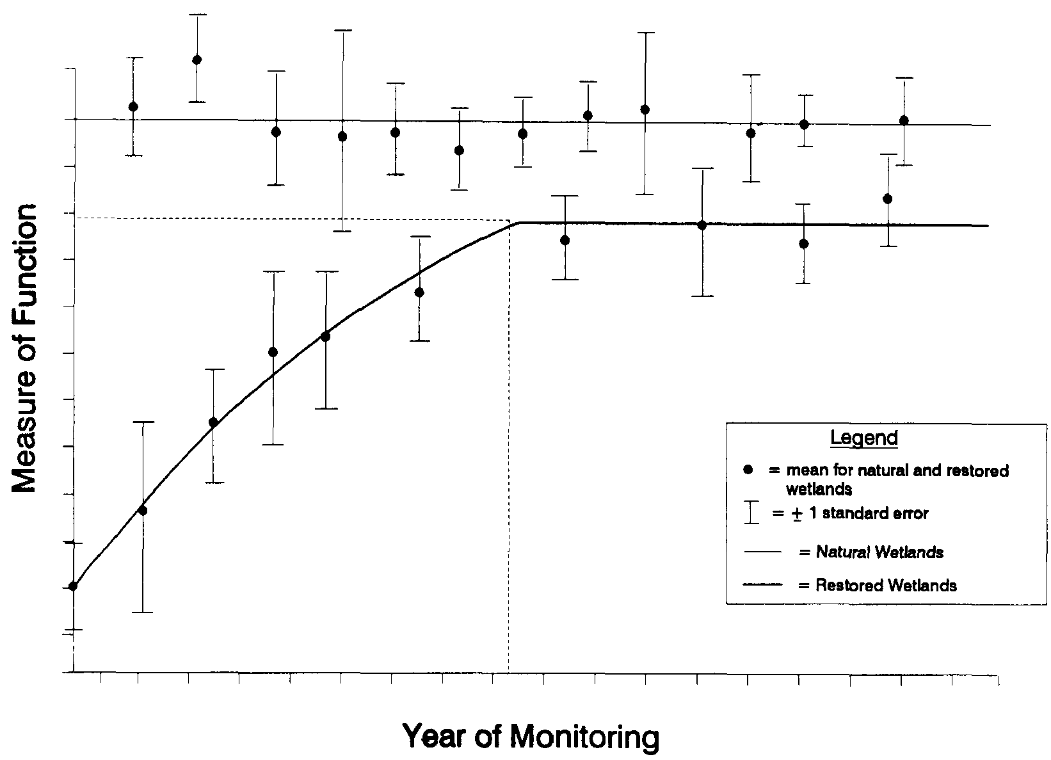
In Oregon, we looked at young projects, mostly under five years of age, and at the entire population of projects in the study area. An example of a performance curve from the study uses soil organic matter as an indicator of the projects' development. The projects contained less organic matter than typically present in the soil of similar natural wetlands. We would expect soil organic matter to increase with time on the projects and become more like that in natural wetlands. This summer, we will look at these sites again to see if that has happened.

## Repeating Patterns

How do we use this for performance criteria? Our data tends to show the same patterns over and over again—whether in Connecticut, Florida, or Oregon. In this case, we looked at the ability of a site to maintain a diversity of plants typical of the wetlands in that setting. The projects are more diverse than the natural wetlands, which you might expect in an area that had just opened up for colonization. You would expect project diversity to decrease with time as cover and competition increased.

In examining our data, you see projects that are not acting the same as the others: A project receiving runoff from a parking garage with an abundance of oil-based products reflected this impact in the values of a number of indicators we measured. So information on the development of groups of projects can tell you sites that

**Figure 1.—Hypothetical performance curve.**




are in trouble. The data suggests a performance criterion that, if the project is developing as expected, the plant diversity on these types of projects, within two years after the project is completed and definitely within five, should be greater than or equal to what you see in similar natural wetlands in that same setting.

## Viewing Data Differently

Through this method, we can look at the same data a little differently and tie it to the project design. We found that very few of the species on the planting lists for the sites were actually on the sites when we went there. That meant that the planting lists from the project plans were virtually meaningless.

However, we found a good overlap with the species on similar natural wetlands. In looking at the same data, but now including species cover, the pattern does not change. Again it indicates that the planting lists from the plans do not reflect what we are finding on either the projects or natural wetlands. These data suggest another performance criterion. Within two years and definitely within five years after a project goes into the ground, we expect to see between 60 and 70 percent of the kinds of species occurring in similar natural wetlands. If the species are not found on the site, the site is likely in trouble.

In looking at native and exotic species, the patterns we saw in the natural wetlands were what we were seeing in the projects. In an urban environment, this surely reflects the urban setting of the mitigation projects and the natural wetlands.

These few short examples show how monitoring information can be used to set quantitative performance criteria. We need to use the projects as experiments to learn from them and to learn more about our natural systems. ❑

PANEL: *Measuring Success*

# *Restoration Evaluation*

John J. Berger
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This presentation will provide some background on measuring restoration success, monitoring measures, the evaluation process, and assessment criteria. To set the stage, I will offer a few definitions, make some distinctions, and provide a perspective on the attributes of restoration success.

## Taking an Ecosystem's Pulse

Monitoring is essentially real-time data collection and observation. Figuratively speaking, it could be compared to taking the ecosystem's temperature, doing the patient's blood chemistry, looking at the skin color, and checking that the eyes are bright and shiny, the tail is wagging, and the nose is wet.

We engage in monitoring for various reasons. We might, for example, be conducting a construction review and monitor to simply determine that all construction conditions and design specifications have been met. As mentioned in an earlier talk, a project designer should be on site when the actual construction is going forward. Another motivation for monitoring is permit compliance. This can also be regulatory compliance in a broad sense.

A third reason for monitoring is to determine whether the project is meeting a broadly construed set of ecological goals to relate the project to a natural ecosystem design model.

## Making a Diagnosis

In contrast to monitoring, evaluation is a synthesis and judgment about the ecosystem based on that monitoring data. Evaluation might be equivalent to making the patient's diagnosis. Is the patient sick or well? If sick, how sick? If well, how well? What are the causes of the conditions? What is the "pulse" of an ecosystem, and what is its "temperature?" Are those meaningful concepts? Are there any such things? If not, what would be the most useful analogue of these characteristics?

Before answering, let me pose some questions. Suppose that Ducks Unlimited, the conservation organization, floods a field, enabling some wetland plants to grow for several seasons and inducing some ducks and geese to use the area. Is restoration success best measured by percent of aerial coverage by wetland plants? Or is it best reflected by percent of plant survival, percent of open water, or by some indication that you have successfully approximated the site's hydrology and gradient? Is it best expressed by the average number of active nest sites? Should we abandon that approach and look at the beneficial effects of the project on interconnected lakes or on other interconnected aquatic ecosystems?

## Wrestling with Data

This latter consideration harkens back to the integrated ecosystem management approach that Dan Willard contributed to the *Restoration of Aquatic Ecosystems*, a study for the National Research Council. Suppose we say that no single measure can adequately reflect restoration success and, for the sake of argument, we use multiple measures or indicators. Does that solve our problem?

Consider the National Estuary Program that has supported Chesapeake Bay restoration. We know what we want in Chesapeake Bay—clean water, nutrient reduction, and toxics reduction. We want plenty of crabs and oysters and striped bass. But suppose our restoration effort produces fewer blue crabs and more oysters, more submerged aquatic vegetation but also more coliform bacteria, or more dissolved nitrogen but less dissolved phosphorous.

While these precise outcomes may be ecologically improbable, the point is this: What do you do when your monitoring results are contradictory, when you have both disparate and incommensurable indicators? How do you synthesize this disparate array of attributes of an altered ecosystem to measure restoration success? In evaluation jargon, this problem is called "a multi-attribute decision analysis problem" and is somewhat amenable to decision theory. Is this nomenclature and the concept it represents just an empty formalism?

On the contrary, thinking in terms of a multi-attribute decision problem at times is important. This is true, for example, when considering alternative candidate sites for restoration and when comparing results of a restoration effort to project goals, or simply when trying to compare the wildlife support values of two or more ecosystems. The restoration practitioner might also use comparative analysis to convince a funding agency (or other decisionmakers) that a restoration effort was a success, or that it had failed and another avenue should be pursued.

## Restoration—Dual Meanings

As previous presenters have pointed out, restoration may mean *whole-system restoration* or *attribute restoration.* The latter encompasses restoring an aspect of an ecosystem—a structural or functional characteristic. For example, this might include clean water in a lake, sinuousity of a stream, the approximate original contour of a mine site, a particular vegetational component of an ecosystem, or a single species. Sometimes restoring a single species may actually require the restoration of a whole ecosystem, as Charlie Wooley pointed out regarding the Great Lakes.

Restoration of the whole ecosystem is returning it to an approximation of its condition before the disturbance. This has biological, physical, and chemical dimensions. It involves restoring dynamic ecosystem processes, such as succession, food web interactions, predator-prey relationships, and nutrient and population cycles. It also involves symbiosis and mutualism and, in general, creature-to-creature interaction, creature-to-environment interactions, and interactions between the altered system and its surroundings, via inflows and outflows.

Dynamic processes can also be viewed from another perspective—as ecosystem services, such as groundwater recharge or surface water purification. Dynamic processes also pertain to responses to disturbances—including high amplitude and low probability disturbances, such as floods, spates, or droughts—that the restored ecosystem must withstand. The complexity of natural ecosystems evolving through geological time makes a perfect whole-ecosystem restoration truly impossible. So restoration is an ideal to strive for and must be measured relative to antecedent conditions, or to some surrogates of those conditions.

## Choosing Performance Indicators

To measure performance, we need appropriate indicators. But how do we choose them? That depends on the type of restoration—whether it is whole system or attribute restoration—and more broadly on the restoration's goals and objectives. It also depends on your chosen baseline and target conditions.

How do you ascertain what antecedent conditions were? To do so, you might use forensic ecology—for example, examining pollen grains from sediment cores in a marsh to determine previous vegetation, or aerial photos and historical maps to determine predisturbance topography. Or you might look at collections of wildlife in a museum to reconstruct a species inventory.

Thinking about project evaluation early in the restoration planning process is a good idea, since it alerts you to the need to gather the requisite yet ephemeral preproject baseline data essential for later evaluation.

Once you have a good idea of the ecosystem's antecedent conditions (and thus, implicitly, an indication of its restoration potential), you can then formulate sensible restoration goals and objectives for the ecosystem.

When specific goals and objectives are clearly articulated, you can begin identifying performance indicators. Because performance indicators must be linked to project goals and objectives, the goals and objectives must come first. Next, the performance indicators ideally should be expressed through the ecosystem's structural and functional characteristics and dynamic processes. Structure, function, and process are basic to defining an ecosystem.

Choosing performance indicators is an art and science. One guideline to use to conserve monitoring effort is to rely on integrative ecosystem measures. An integrative measure is likely to be a cost-effective monitoring choice, because the integrative measure's status depends on, and therefore subsumes, a host of subordinate ecological preconditions. The measure, therefore, indicates ecosystem function on a range of other variables. An example of an integrative measure is ecosystem carrying capacity for some upper trophic web organism whose presence requires integrity of the food webs below.

Another integrative measure might be a keystone species, or the quantity of some particularly fragile and exigent species, since that species' presence would indicate that a range of preconditions have been met, and they would not therefore have to be explicitly monitored.

Once performance indicators have been chosen, then the sampling and statistics to validate restoration are similar to those used in any typical field ecology experiment.

## Restoration Success Elements

We cannot, through restoration, suspend an ecosystem at a moment in time like a biological specimen in a bottle of formalin. However, we can adopt a turn-key approach in restoration.

In industry, a turn-key plant is built by the architect-engineer, who gives the customer the key. All the customer need do is turn the key and operate the facility. In restoration, a true success would be an ecosystem reconstruction project after which we could metaphorically turn the keys back to nature. Nature, as the principal manager, would not need to rely on engineered structures and fallible human maintenance to keep the ecosystem operating in a healthy and naturalistic manner.

While "hands off" turn-key operations may be ideal, in the real world of fragmented ecosystems, we are dealing with ecosystems heavily influenced by humans. So, under the best of circumstances, we must provide for long-term maintenance through ecosystem management, including monitoring and protection. Long-term protection of the restoration project may be as important to the effort's success as was cessation of the initial disturbance (generally a precondition of restoration success).

## Finding Solutions

What about the solutions to the multiattribute problem mentioned earlier when monitoring produces disparate and incommensurable data? First, we must organize and display that monitoring data in a clear and systematic way, grouping similar kinds of data together. Then we can synthesize data that are truly comparable and alike.

At this point we must avoid the pitfall of trying to commensurate inherently incommensurable data. An example of this error would be to assign index numbers to incommensurable factors and average the index numbers, coming up with some metric supposedly reflective of ecosystem success. We would then rank the project with that relative number. But we would have performed an essentially meaningless exercise.

By contrast, at the outset of the evaluation process, we can give initial importance values to the most important project effects for which we are striving, and we can rank order those importance values. Later, with disparate and incommensurable data arriving, we can look back to see what we ranked as truly important and incorporate our new findings in the evaluation with reference to that initial rating schema. Tempting as it may seem, we need to avoid trying to employ a single success index or common metric or single number to evaluate our restoration success with a complex ecosystem having many dynamic features.

■ Question: You talked about key indicators, like keystone species, and not success indicators in wetland restoration. These indicators might show up at the end of a successful creation. At a quarter or third of the way through, how do we know when to make corrective measures? Will we likely see these indicators at the end?

■ Answer—John Berger: Surprises occur often in natural systems. But if you have studied the system well, done preproject assessments, and looked carefully at comparable reference ecosystems and their natural successional processes, then you will minimize the chance of encountering an untoward surprise.

Naturally, the reference ecosystem needs to be chosen in a similar ecoregion, using ecoregion typology—or some other equivalent typology—in a similar landscape setting with similar outside influences, substrates, and hydrology. ❑

*PANEL: Measuring Success*

# *Uncharted Territory—Relocating Threatened Plants and Reconstructing Lakeplain Prairie Habitat*

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This presentation discusses a threatened species mitigation project. The project shows by example some of the permitting standards and tools available and used by the Michigan Natural Heritage Program. The presentation also calls for a broader approach to endangered and threatened species protection and recovery in Michigan and shows how this need pertains to the regulation of federally listed species, particularly plants.

The Michigan Department of Natural Resources (DNR) Natural Heritage Program consists of several programs: Non-Game Wildlife, Living Resources, Natural Beauty Roads, Wilderness and Natural Areas, Endangered Species, and the Michigan Natural Features Inventory (MNFI). The Endangered Species Program administers the Michigan Endangered Species Act, Public Act 203 of 1974, and works cooperatively with the U. S. Fish and Wildlife Service to recover federally listed species.

MNFI, part of The Nature Conservancy's Science Division, works in cooperation with Michigan DNR and is responsible for an ongoing statewide inventory of endangered, threatened, and special-concern species and high quality natural communities, and other features (collectively known as "elements"). MNFI also maintains a data base on approximately 9,000 element occurrences. The MNFI is part of an international Heritage Network linking similar programs in all 50 states and several in Canada, in Central and South America, and more recently in Southeast Asia.

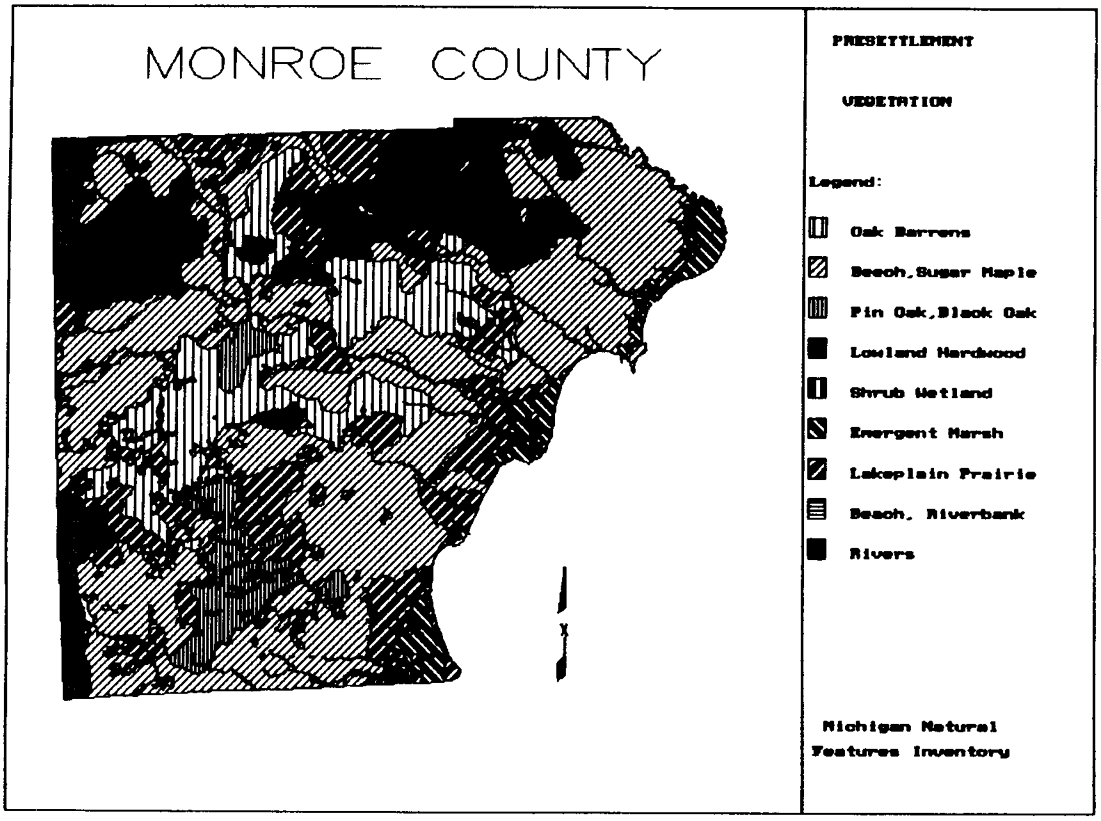
MNFI staff provided invaluable assistance in increasing our understanding of the lakeplain prairie ecosystem and the project species. Before establishing standards for a successful restoration, base line parameters must be determined. In doing so, the best available information on species ecology, natural communities, and ecosystems being restored must be used.

## A Critically Imperiled Community

The Algonac Prairie in St. Clair County is one of six remnant lakeplain prairies known regionally and, in fact, worldwide. Lakeplain prairie is critically imperiled and has a proposed ranking of G1/S1 (see definitions), according to The Nature Conservancy (Nat. Conserv. 1982). The lakeplain prairies are also home to several state and federally listed plant species. At a lakeplain prairie recently discovered in Wayne County, 176 native plant species have been documented—14 of which are rare—and tracked in the MNFI data base. One species that typically grows in lakeplain prairies is the eastern prairie fringed orchid *(Platanthera leucophaea)*, listed as threatened under the Federal Endangered Species Act. EPA has provided funds for restoration and monitoring of the ecological processes, flora, and fauna within the lakeplain prairie at Algonac and other sites. Research will soon provide valuable insights into this critically imperiled ecosystem.

Extensive proglacial lakes Maumee and Whittlesey covered Wayne and Monroe counties approximately 13,000 years ago (Door and Eschman, 1977). The receding glaciers deposited fine silts and clay in this proglacial lake. Sand was both eroded from end moraines and deposited in broad channels over the clay lakebed by glacial melt water streams (Albert, 1990). These sand channels were reworked into a series of shoreline features such as low dunes, beach

**Figure 1.—Monroe County presettlement vegetation.**




**Source:** *Comer et al. 1993.*

ridges (uplands), and intervening depressions (wetlands) during higher levels of the Great Lakes (Comer and Albert et al. 1993).

## Presettlement Vegetation

In 1816, the General Land Office (GLO) began surveys in Michigan. From GLO survey notes and other historical records, MNFI ecologists, with the assistance of a NOAA Coastal Zone Management Program grant, constructed presettlement vegetation maps of the Great Lakes coastal zone. This project also included the entire lakeplain of southeast Michigan.

The presettlement vegetation information was digitized and used to prepare a map of Monroe County (Fig. 1). (EPA has provided funds to substantially complete the GLO interpretation and create a digital data base of the entire state with emphasis on presettlement wetlands.) Native presettlement communities on Monroe County's clay lakeplain consist of upland hardwoods dominated by American beech, sugar maple, white oak, American elm, and hickory (44 percent of the county) and lowland hardwoods dominated by black ash, American elm, and basswood, with cottonwood, sycamore, aspen, and red or silver maple (Comer and Albert et al. 1993). On the sand lakeplain, the uplands supported oak barrens, also known as lakeplain oak openings or savannas, and some dry prairie; the wetlands supported wet prairie and marshes. White and black oak were the prairie's most common oaks (Comer and Albert et al. 1993). Along the Lake Erie shoreline, lakeplain prairie graded into extensive Great Lakes marsh communities (Comer and Albert et al. 1993).

The digital data base was used within a Geographic Information System (GIS) to assess changes in the landscape since presettlement times. Monroe County today contains 12.5 percent of the approximately 164,000 acres of presettlement wetland types that covered about half the county (Comer and Albert et al. 1993). Monroe County had approximately 56,000 acres of lakeplain prairie during presettlement. Hubbard (1838), describing Monroe County's wet prairies, stated that approximately one-fifth of Wayne County consisted of wet, grassy prairies, and one-third was oak openings (Chapman, 1984).

Chapman estimated the savanna-wet prairie complex in Wayne County to have covered approximately 38,000 acres.

## The Lakeplain Prairie Drained and Farmed

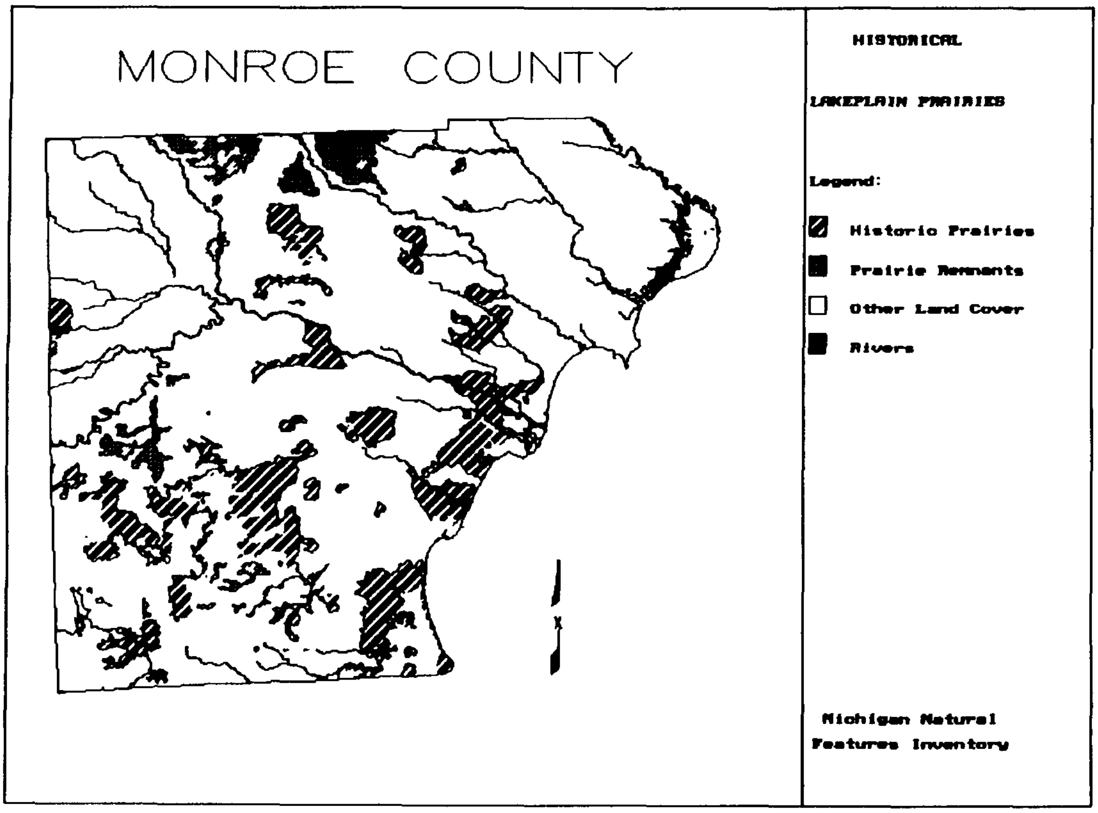
Since European settlement, Michigan's 100,000-acres lakeplain-wet prairie has been reduced to some 500 acres, or one-half percent of its original acreage. In other words, 99.5 percent of this system is gone from Michigan. No intact examples remain of the original 500,000 acres of oak openings. These habitats were primarily lost through extensive drainage and conversion to agriculture. Many sand dunes and beach ridges were built upon or "borrowed" for use elsewhere, and Native Americans ceased burning the landscape. As a result, any remaining savannas or woodlands have succeeded to closed canopy forests (Comer and Albert et al. 1993).

The Saginaw Bay Prairies, showing a slightly different system, illustrates a farmed area, with natural communities remaining along the coast. Great Lakes marsh grades into prairie and degraded savanna on the higher sand ridges. An area adjacent to a wetland is a logical choice for reverting farmland back to wetland. The presettlement vegetation interpretation and the GIS analysis are useful tools for finding restorable wetlands as shown in Monroe County (Fig. 2) (Comer and Albert et al. 1993).

## Hydrology and Fire

Natural processes—including seasonal and annual fluctuations in the surface water, fire, and grazing—maintained these systems. Because of the level topography, underlying clay close to the surface, and one-time proximity to Lakes Huron and Erie, the lakeplain ecosystem continues to experience seasonal and long-term water-level fluctuations from precipitation events and changing lake levels (Comer and Albert et al. 1993). Periodic and sustained high water tables helped kill woody vegetation, thus maintaining a mosaic of open prairie in areas transitional from marsh to wooded beach ridges. Today, these same processes help keep some remnant prairies open. However in most areas, agricultural drains have lowered the water table, converting wet prairies to lowland hardwoods (Comer and Albert et al. 1993).

**Figure 2.—Monroe Country prairie vegetation.**




**Source:** *Comer et al. 1993.*

Because of this drying out effect, fire is an increasingly important tool in lakeplain prairie restoration. Early European accounts and anecdotal information indicate that Native Americans burned the area annually, a practice which helped maintain the prairies. In 1907, Geib wrote that the "openings" presented the appearance of an immense plain. Every fall, Indians burned the land over, not only keeping the annual vegetation burned off but also the young tree growth. According to artifacts found near the Wayne County mitigation site, Native Americans used the higher and sandy beach ridges for traveling, camping, and hunting. Prior to European settlement, buffalo also roamed the landscape (Chapman, 1984), although we do not understand their ecological role within the lakeplain ecosystem. While we are still learning about the plants and animals, we have fairly good understanding of how the system works.

## An Airport Expansion—Project History

In 1989, the federal and state transportation departments completed an environmental impact statement (EIS) to expand the Detroit Metropolitan Wayne County Airport. Construction was anticipated to adversely affect three threatened plant species protected under the Michigan Endangered Species Act (1974 PA 203). Although threatened species' presence was known before the final environmental impact statement was printed (U.S. Dept. Trans. 1989), the document mentioned neither the impacts to threatened species nor the wetland systems' uniqueness.

The MDNR Land and Water Management Division and Wildlife Division staffs worked cooperatively with the consulting firm to establish the site-specific information necessary to meet of the Endangered Species Act's statutory requirements. However, prior to an August 1990 site survey requested by the MDNR endangered species coordinator, areas on the project site, which had previously been identified as containing threatened plant populations, were cleared of vegetation. This resulted in the destruction of threatened plants and was a violation of the Endangered Species Act. Also, as a result of the delay in discovering the site's significance, the 400-acre wetland mitigation plan did not take into account the significance of the lakeplain prairie complex.

The statutory requirements of the Michigan Endangered Species Act (M-ESA) were enhanced by making compliance with the Endangered Species Act a condition of the wetland permit (#90-14-274, dated May 30, 1990) issued to the Metro Airport Authority under the Goemaere-Anderson Wetland Protection Act (1989 PA 203). M-ESA provisions were negotiated through a State Endangered Species permit, needed for continued construction within the airport's affected areas.

Natural communities, as defined by Chapman (1986), include a complex of mesic southern forest, southern swamp forest, lakeplain wet-mesic prairie, and mesic sand prairie. These communities function within a relatively intact landscape ecosystem, as defined by Albert et al. (1986). Building the airport runway and facilities will have both direct and indirect effects on the state-listed threatened species, which have affinities to the Atlantic Coastal Plain: *Aristida longispica* (slender three-awned grass), *Juncus brachycarpus* (short fruited rush), and *Ludwigia alternifolia* (seed box).

The *Aristida longispica* on the airport property represents Michigan's largest known population of this state-threatened species. *Aristida longispica* is present in 11 state localities, only a few of which were recently recorded and one-third of which are in Wayne County (Penskar and Crispin, 1993). Threatened species localities may or may not co-occur with a high quality natural community; this is true in some airport areas. For example, all the known populations of *Aristida longispica* occur on remnants of the once extensive lakeplain. Several of these populations occur in very degraded habitats in southeast Michigan but are not growing in large, functioning ecosystems or plant communities.

*Juncus brachycarpus* is found on 10 localities statewide and *Ludwigia alternifolia* on 16 localities, including the airport site and the mitigation site (Penskar and Crispin, 1993). Both state-threatened species are almost entirely restricted to poorly drained post-glacial lakeplain. Approximately 11 additional state special-concern species at the airport are also being affected.

## Mitigation Alternatives

Near the airport, an MNFI ecologist discovered a nearly intact lakeplain prairie and lowland hardwood complex, an ideal site for restoration and enhancement. MNFI staff has documented over 160 native species and approximately 17 special plants, including the species at the airport, which number in the hundreds if not thousands. This was an amazing find. But acquiring the 600-acre site would have cost $1 to 4 million. Therefore, acquisition and enhancement at this stage of the permit negotiation was not feasible.

The chosen alternative was to relocate the affected plants offsite and manage the remaining populations on the airport site. Therefore, Wayne County bought the approximately 20-acre, primarily old field site for threatened species relocation to add to the 400-acre wetland mitigation. Relocation and restoration is being attempted at an estimated cost of $100,000.

This mitigation is expected to result in the recolonization of primarily agricultural land by non-native weeds (exotics), such as purple loosestrife or cockelbur, and native species with low coefficients of conservatism (0–3), such as cattail and reed canary grass (Wilhelm, 1991a; Albert and Reznicek, personal communication, 1991). Information available from EPA's *Wetland Creation and Restoration: The Status of the Science* reveals a paucity of information and lack of success in creating wetland communities in the Midwest containing sensitive species such as threatened species from the airport site. Wilhelm (1991a and b, 1993) also reports little success in mitigating wetlands in Lake County, Illinois, and the Chicago region, which contain highly conservative plants with coefficients of conservatism of 8 to 10, as defined by Wilhelm and Ladd (1988).

## The Michigan Floristic Quality Assessment System

The consultant's initial floristic information on airport threatened species sites was used to determine mean floristic quality (Wilhelm and Ladd, 1988; Herman and Penskar et al. In prep.). This method has been used as a tool by the Army Corp of Engineers' Chicago regional office (Evans, 1990). The northern Ohio Corp of Engineers (Andreas, 1993) is also developing the method to standardize comparisons among wetlands and subsequently to base decisions on wetlands permitting, mitigation, and monitoring. The system assumes that the quality of the vascular flora is a gauge to overall synecological health.

Mean floristic quality calculated from the airport sites with threatened plant species, using the Michigan list of coefficients of conservatism (Herman and Penskar et al. In prep.), range between 3.8 and 6.44, an indication of relatively high floristic quality. Wilhelm reports that a wet prairie restoration at the Des Plains River Wetland Demonstration Project attained a mean floristic quality of 3.34 after planting, even after four years of data collection (Wilhelm, personal communication, 1991). Although the ecosystems and plant constellations differ for Illinois and Michigan, these data suggest that, under the best circumstances, the ecosystem is unlikely to be restored given the unknown and unproven technology for a lake-plain ecosystem with a mean floristic quality already above 3.34.

In addition, we know little about the autecology of the affected species. But because we wanted to avoid direct destruction of these plants, we decided to find out if the method would work.

## Relocating Threatened Species

The project's purpose was to move threatened plants from areas affected by the airport expansion and to protect the remaining plant communities (Michigan Dep. Nat. Resour. 1992). The consulting firm supervised the relocations and a qualified botanist approved by the endangered species coordinator is monitoring the efforts. Site conditions were matched as closely as possible before relocating the plants. Photographs and written annual reports document the efforts.

Approximately 150 *Ludwigia alternifolia* and 350 *Juncus brachycarpus* plants from the airport and the seed bank of approximately 1.32 million *Aristida longispica* plants and 50 *Juncus brachycarpus* were relocated. Soil plugs at the mitigation site were extracted and soil plugs containing the plants were moved into holes with a 60-inch-diameter tree spade. The consultant planted by hand approximately 50 *Ludwigia alternifolia* seedlings grown indoors.

At the mitigation site approximately a half-acre was stripped of 3 to 5 inches of existing herbaceous and woody vegetation and topsoil. New topsoil containing the *Aristida longispica* seedbank was spread in a 3-inch layer over the prepared mitigation site. After 20 soil plugs were moved, approximately 300 cubic yards of topsoil containing seeds and rhizomes of remaining *Juncus brachycarpus* plants and other plant species were excavated from the airport and moved to the mitigation site.

## Reconstructing the Prairie

The goal of excavation and finished grading was to match the airport's surface hydrology. Approximately 1,000 cubic yards, and an additional 2,000 cubic yards, were excavated from 0.4 acre of the mitigation site. The new soil surface was as much as 22 inches lower than the previous grade. The earthwork contractor, who surveyed finish grades to verify elevations, limited soil compaction by using small machinery to spread the top soil. Finish grading was coarse, with roots and plant material left and allowed to settle naturally. The mitigation site has been fenced off. A management plan is in place both at the mitigation site and the airport, and surface water levels and vegetation are being monitored biweekly throughout the growing season for the first five years.

The threatened plant populations at the airport and the mitigation site will be monitored in two successive five-year periods—from 1992 to 1996 and from 1997 to 2002. In the first period, monitoring is more frequent than in the second period. The second period will begin when the endangered species coordinator determines that the threatened plants are well established.

Hydrology at each study site is monitored biweekly from April 1 through October 31. Monitoring is done by measuring static water levels in standard monitoring wells at both ends of each vegetation sampling transect. From November through March, monitoring is done monthly. When static water levels are recorded, a portable tensiometer records the soil moisture at a depth of 10 centimeters in each plot along the transects. If standing water is present, its depth is measured in each plot. During the second period of monitoring, static water levels will be recorded twice a year, in late spring and late summer.

All vegetation is being assessed. Monitors record cover and abundance data for each species and photograph each plot. If threatened or special-concern plant species appear within a plot, monitors make separate counts of the juvenile and mature (flowering and fruiting) individuals. In addition to gathering plot data, monitors conduct random walks of each site to identify those species not present in the plots.

To assess the survival success of the threatened species relocated in the soil plugs, permanent vegetation monitoring plots have been established. Within each plot, monitors count each individual *Ludwigia alternifolia* and *Juncus brachycarpus* and record the following data: number of seedlings, juveniles, and adults, plant height, number of stems, numbers of flowers and fruits per stem for *Ludwigia alternifolia,* and numbers of flowering and fruiting infloresences per stem for *Juncus brachycarpus.*

Monitors tagged 20 individuals of each species and followed them throughout the monitoring period. Hand transplants were similarly tagged and followed. We required a control of four quadrats for each species for *Ludwigia alternifolia* at the mitigation site and for *Juncus brachycarpus* at the airport. In addition, counts of threatened plants are recorded annually at the mitigation site. At all sites, monitors estimate the total number of individuals of *Aristida longispica* by counting a minimum of two quarter-meter-square plots and extrapolating the results to the total area occupied by the species. Numbers of flowering and fruiting individuals are counted for each plot.

## Annual reporting

For each site or area, hydrologic data include a set of graphs, including precipitation, soil moisture, and static water level data plotted against time for all transect plots at the airport. Vegetation data are integrated with hydrologic data by graphing surface and clay layer elevations (topography), mean static water level, minimum and maximum water level, threatened species populations, and the wetness index developed by Wilhelm (1991a and b).

Data are used to calculate species diversity indices for native species alone and combined with non-natives. Similarly, the Michigan Floristic Quality Assessment System tracks and compares floristic quality of both the plots and total for each site and integrates it into the topographic and hydrologic data. All data, including threatened species data, are compared statistically between treatments and/or sites.

Figures 3, 4, and 5 from a 1992 report by Johnson, Johnson, & Roy, Inc. show base line data from the airport site. Figure 3 shows the fluctuations of the water table over one growing season, including dry periods in mid-July and early September. Figures 4 and 5, in particular, show how the plants, as measured by a wetland index (Wilhelm, 1991a), reflect both the site's hydrology and topography.

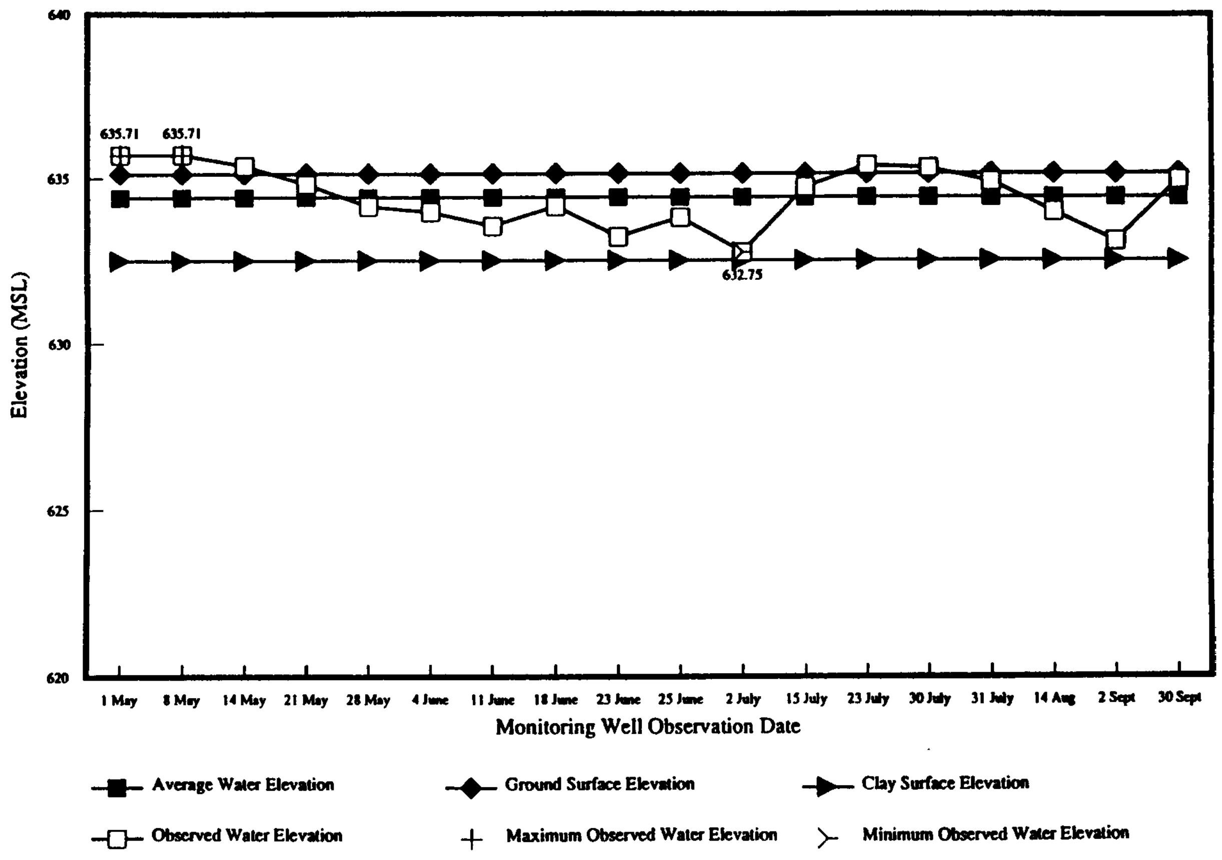
The management goal is to maintain the viability of the threatened plant species populations and maintain or improve the floristic quality of the airport and mitigation site areas. The permittee must submit for approval a long-term vegetation management plan for the airport mitigation sites to the MDNR endangered species coordinator. The plan must include a prescribed burn management plan and possible mechanical or hand clearing plan. Specific details of the plan may need adjusting, pending analysis and review of vegetation data.

At minimum, the permittee must acquire, through letter and formal presentation, a variance of the Wayne County pollution control ordinance and a permit from the County Health Department's Air Pollution Control Division. The permittee must also attempt to obtain any other Federal Aviation Administration permits, state and local permits, licenses, and insurance before beginning a prescribed burn. The permittee may consider herbicides if an exotic plant problem is present.

## Success Criteria

The MDNR endangered species coordinator uses specific criteria to determine whether the threatened plant mitigation effort has been successful.

**Figure 3.—Summary of monitoring well water level observations, airport west/south well.**




**Source:** *Johnson, Johnson, & Roy. 1992.*

The mitigation site populations of *Ludwigia alternifolia, Juncus brachycarpus,* and *Aristida longispica* must be at least as large and viable as populations eliminated at the airport. Therefore, individual plants must total at least 150 *Ludwigia alternifolia,* 900 *Juncus brachycarpus,* and approximately 1 million *Aristida longispica.* At least 50 percent of these individuals must produce seed in the final year of monitoring to be considered viable.

At the end of the monitoring period, the mitigation area should be free of aggressive weeds, such as purple loosestrife (*Lythrum salicaria*). The diversity index should be stable or show an increase in native species diversity throughout the monitoring period and show a stable or increasing Michigan Floristic Quality Index and mean coefficient of conservatism.

The airport populations of *Ludwigia alternifolia, Juncus brachycarpus,* and *Aristida longispica* should not have undergone any significant decline based on transect and mapping data, and their continued existence should not be threatened (i.e., no permanent reduction of soil moisture caused by drainage of surrounding lands).

## Contingency Measures

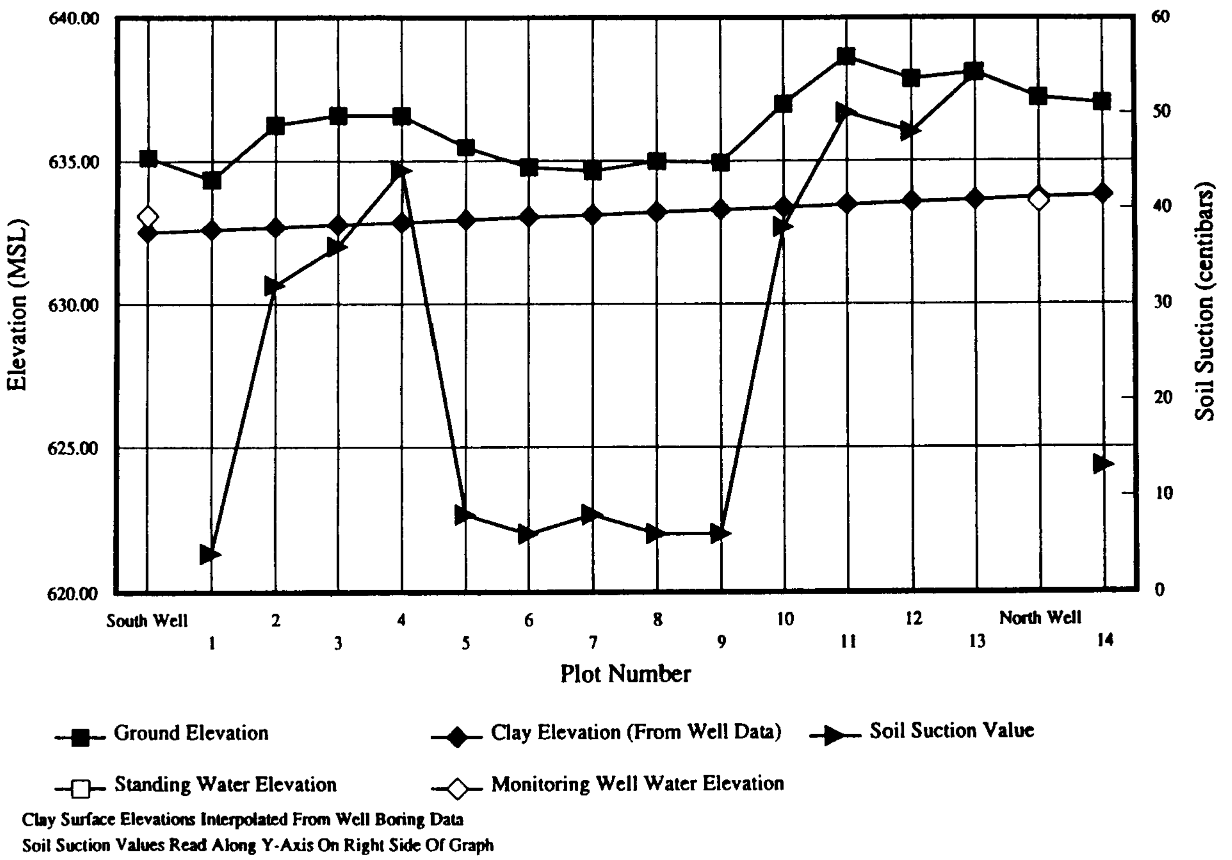
The consultant must propagate both *Juncus brachycarpus* and *Aristida longispica* from seed or from crown divisions, as appropriate, to establish a healthy greenhouse population in case relocation efforts fail in the first five years. As soon as the plants' failure to thrive becomes apparent, the probable cause must be identified and corrected. If the cause is improper water levels, portions of the mitigation area may need to be deepened or filled or the management strategy changed. The MDNR endangered species coordinator must approve corrective measures.

After five years of monitoring, if conclusive evidence indicates that the threatened species mitigation site cannot sustain the threatened species, even with modifications, then a similar but larger and intact mitigation site in Wayne or Monroe counties must be purchased and managed.

After two years of negotiating this permit and a 10-year monitoring period, perhaps we will then know if the effort has been a success.

Michigan is host to 810 species of non-native plants and about 1,800 species of natives plants

**Figure 4.—Airport west transect hydrological data (September 2, 1992).**




**Source:** *Johnson, Johnson, & Roy. 1992.*

(Fig. 6) (Herman and Penskar et. al. In prep.). Some 15 percent of Michigan's native flora is endangered or threatened and another 8 percent is of special concern—a full 23 percent of the native flora is potentially at risk. For the most part, the autecology of these species is unknown, making any mitigation involving transplanting difficult.

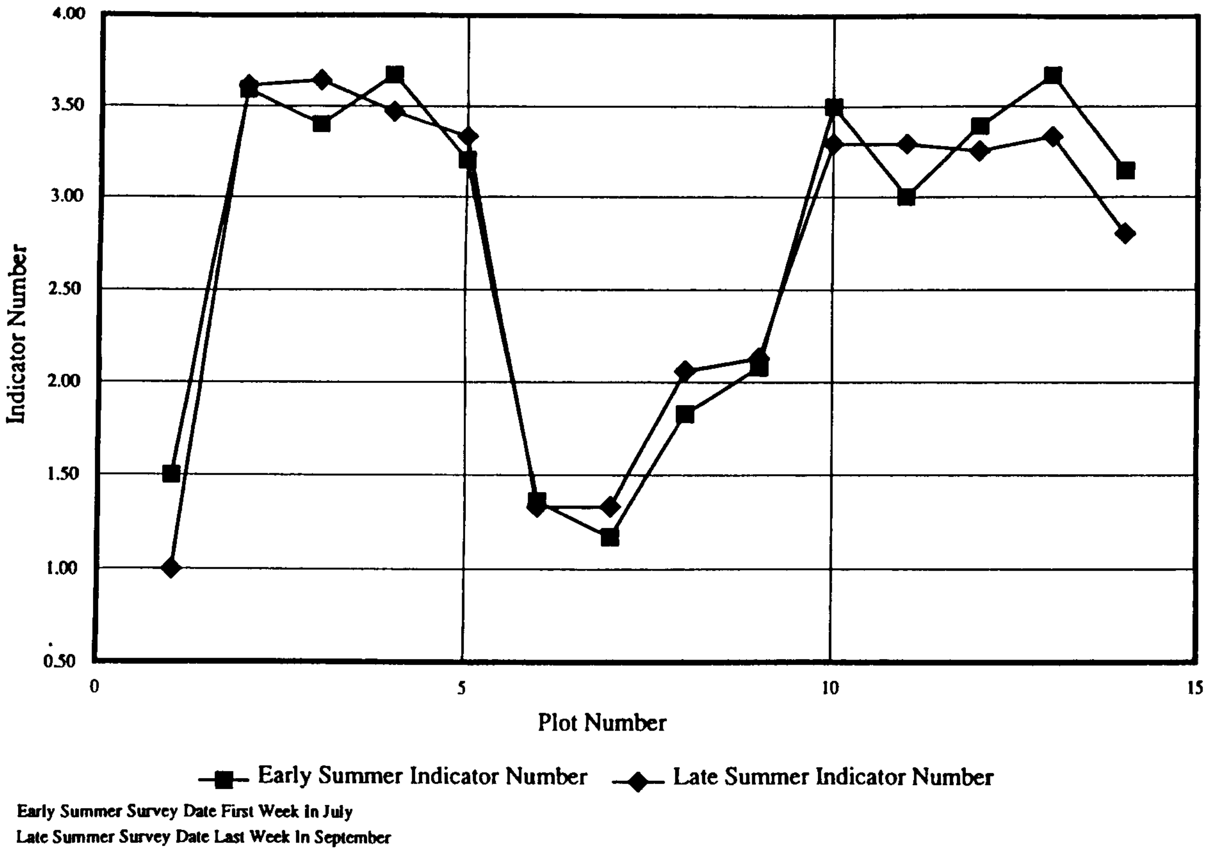
Of the non-native plants, less than 70 species are actually categorized as wetland plants (Fig. 7) (Herman and Penskar et al. In prep.). Our native species, including Michigan's special plants, however, more clearly reflect the landscape, and the number of wetland and upland species are split almost evenly. In addition, nearly 200 species of sedges fall into the wetland categories (Herman and Penskar et al. In prep.). Yet wetland professionals often will document easy-to-identify, non-native flora when completing wetland delineations.

Losing 23 percent of a native flora is a tremendous potential liability. We need to look at the long-term cumulative impacts to constellations of listed species within their habitats and the other alternatives to the "pick-it-up-and-move-it" philosophy. We were unable to use other alternatives at Detroit Metro Airport. The transplanting alternative has become all too common; if it continues, it will result in the loss of species and associated natural communities.

Quite often, project information comes to the Michigan Endangered Species Program at a very late date, especially with state-listed species. For example, in the case of Michigan's U.S. 31 highway, the focus is on the federally listed *Neonympha mitchellii* (Mitchell satyr butterfly). But in fact, the 10-year-old EIS does not contain information on several recently discovered state-listed species. Real opportunities exist for looking at impacts on biodiversity and habitats. Opportunities also exist for restoring state and federally listed plants beyond single species protection techniques, mitigation or, for that matter, traditional wetland mitigation projects.

Another problem for federally and state-listed species occurs on the Great Lakes shoreline. Four federally listed plants are distributed primarily within Michigan: *Cirsium pitcheri* (Pitcher's thistle), *Iris lacustris* (dwarf lake iris), *Solidago houghtonii* (Houghton's goldenrod), and *Mimulus glabratus* var. *michiganensis* (Michigan monkey flower). With well over 10,000 private land owners

**Figure 5.—Average wetland indicator numbers for vegetation in wetland transects, airport west transect.**




**Source:** *Johnson, Johnson, & Roy. 1992.*

along the Great Lakes shoreline, we must come up with other options for protection. One option is education. In addition, the Fish and Wildlife Service could propose equal protection of federally threatened plants to both endangered plants and animals. Section 7 consultation required by the Federal Endangered Species Act for federally funded and initiated projects is cumbersome and lengthy. Under certain conditions, we may consider the concept of habitat conservation planning, including habitat restoration.

## Recommendations

I recommend that Environmental Impact Analysis, as required under the National Environmental Policy Act, include a discussion on cumulative impacts to species, habitats, and natural communities. If available, Heritage Program data or the equivalent, as exemplified by this project, should be used. Up-front inventories by qualified botanists, zoologists, and ecologists should be required on all projects that result in significant environmental impacts. Impacts to state-listed species and their habitats should be considered with federally listed species.

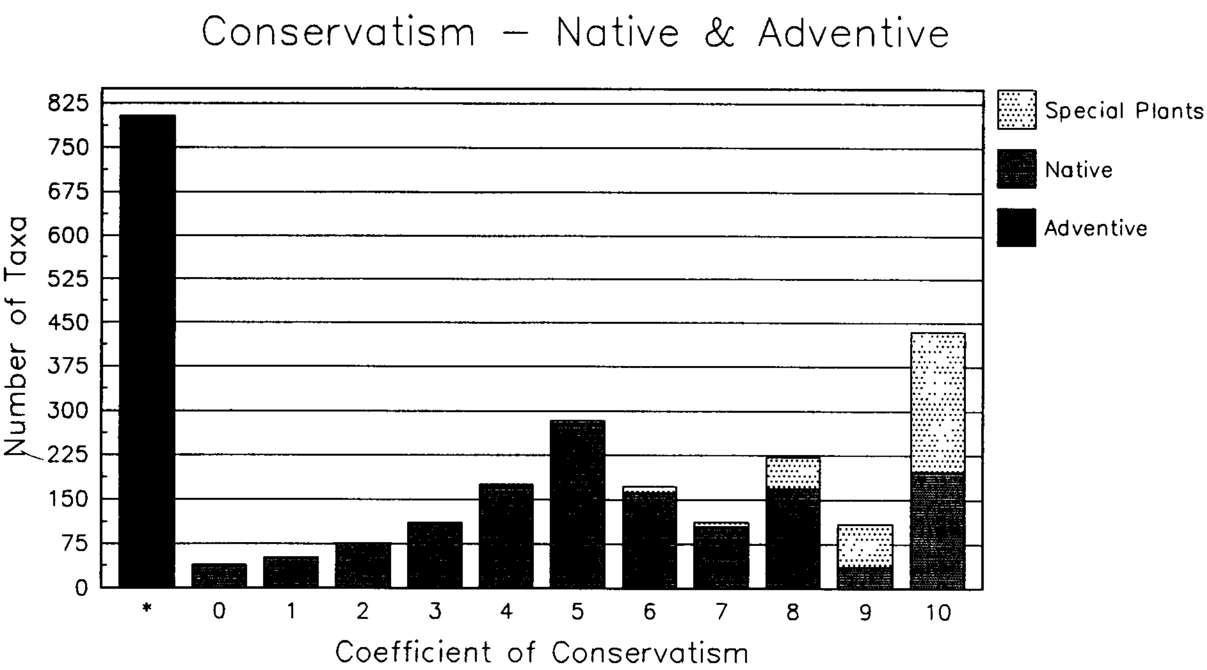
Natural community rarity and its replaceability should be considered in negotiating innovative mitigation agreements to allow the purchase and restoration of existing, yet threatened, high quality natural communities. Replaceability can be measured in part by a floristic quality assessment; standards for success should be measurable, using this project as an example.

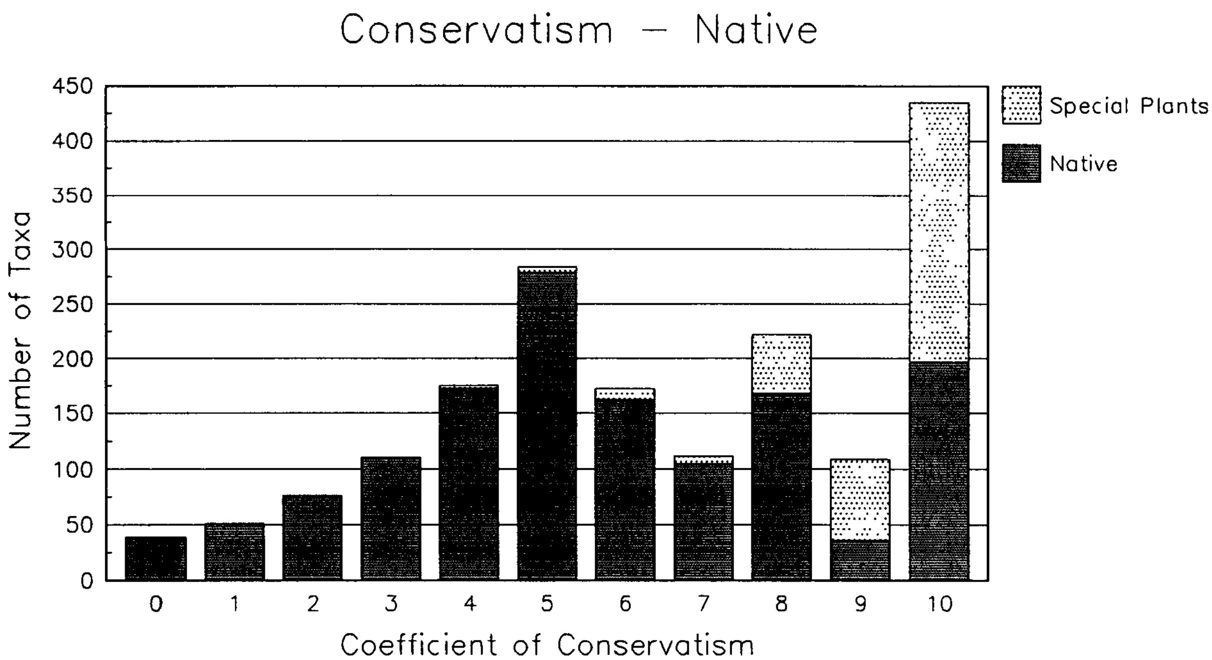
County-wide biological inventories and site surveys should be encouraged and funded to help further our understanding of the current biological resource base. Finally, transplanting and reconstruction should be the last resort for our threatened and endangered plant species. At best, this is always uncharted territory.

## Definitions

**G1/S1 community.** The MNFI provides standardized definitions of global (G) and state (S) element ranks. A G1 community is critically im-

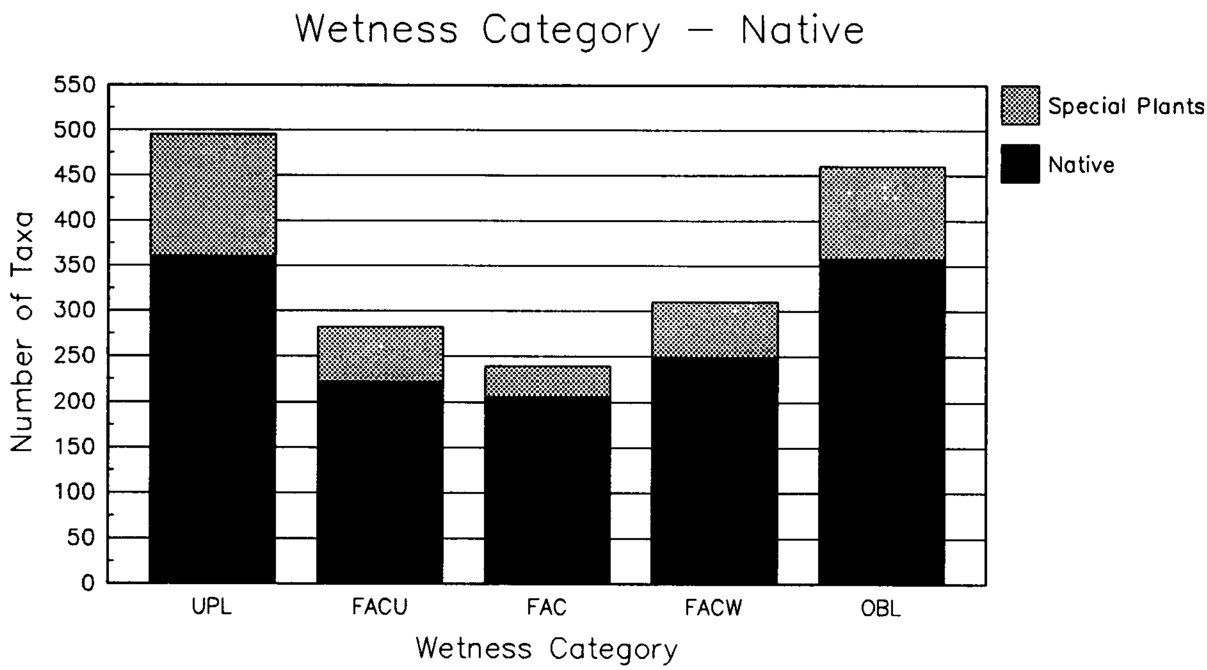
**Figure 6.—Michigan floristic quality assessment system (February 16, 1993).**

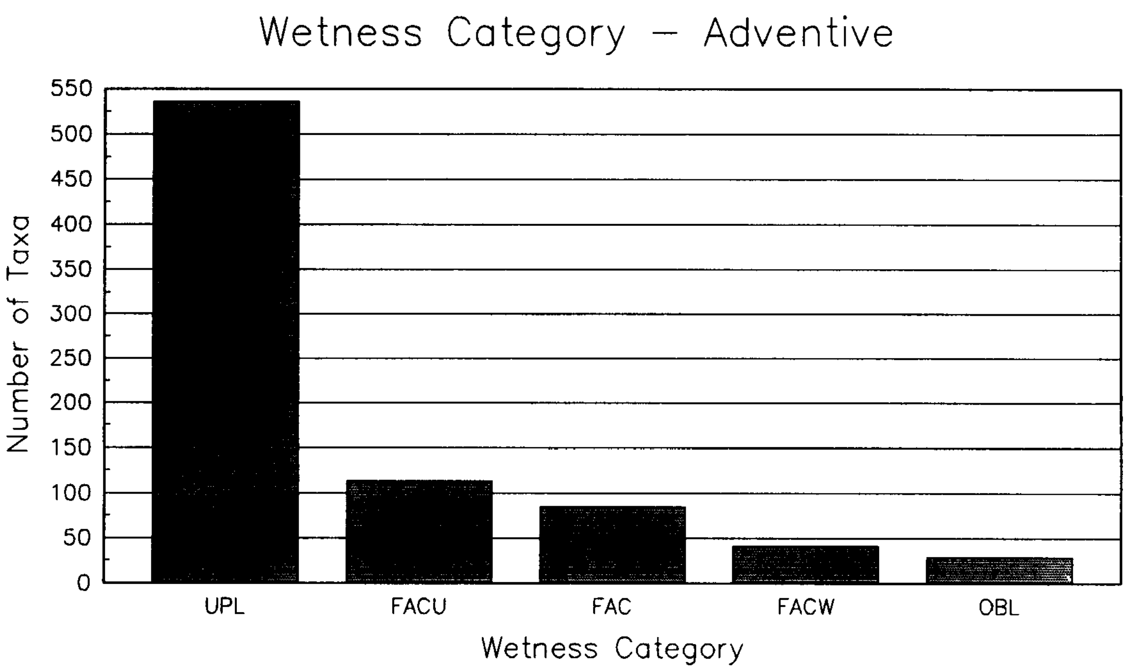



**Source:** *Herman and Penskar et al. (In prep.)*

**Figure 7.—Michigan floristic quality assessment system (February 16, 1993).**




**Source:** *Herman and Penskar et al. (In prep.)*

periled throughout the world because of extreme rarity (five or fewer viable occurrences or very few remaining individual communities or acres) or because of factor(s) making it especially vulnerable to extinction. An S1 community is critically imperiled in the state because of extreme rarity (five or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation.

**Special concern species.** These are sufficiently uncommon so that reductions in their populations or habitat conditions could cause them to become threatened in the foreseeable future.

**Coefficients of conservatism.** As defined by Wilhelm and Ladd (1988), coefficients of conservatism from 0 to 3 apply to species nearly or quite ubiquitous under a broad set of disturbance conditions; values from 4 to 7 apply to species that suggest a pronounced affinity to some native plant community; values from 8 to 10 typify stable or near-climax conditions and exhibit relatively high degrees of fidelity to a narrow range of synecological parameters.

**Mean floristic quality.** This is the sum of the coefficients of conservatism for species known to occur at a site, divided by the total number of species known from the site.

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# General Panel Discussion

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*Corvallis, Oregon*

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*Environmental Science and Policy Consultant*
*El Cerrito, California*

Kim Herman
*Michigan Natural Features Inventory*
*Lansing, Michigan*

Gerould Wilhelm*
*The Morton Arboretum*
*Lisle, Illinois*

* Gerould Wilhelm's presentation was omitted at his request.

**Question:** Gerould Wilhelm made a very convincing case that we lack the ability to restore wetland plant communities. Is the plant community the most important or only important factor to restore? What about other benefits of wildlife habitat and water quality? If you restore 10 to 1 for area, can you make up for the lack of floristic quality of the wetland that you are destroying?

■ **Answer—Gerould Wilhelm:** These issues are relatively limited. We have a list of about a half percent of the total land area in Illinois that has a mean coefficient of conservatism higher than 4. Those areas contain all of the species, the insects, and any other co-evolved organisms in the genetic context or genetic memory of coalescing in a self-sustaining, self-replicating ecosystem. We need to identify and hold on to those areas until we can learn to graft them back into other areas to start holding water again. These systems have the root systems and structure to hold rainwater.

A strong morale question is this: What gives us the right as the stewards of the earth today to obliterate that which we cannot replace? It is as simple as that. If we wind up in 50 years with nothing in the north temperate zone except a bunch of weeds with no diversity or co-evolved organisms to allow the formation of a self-sustaining, self-replicating system, we will be stuck forever with lawn mowers and all manner of heavy maintenance on our landscapes.

So, this is a practical question. How can we build a new economy out of weeds? If the earth is going to have a genuine revival and a living restoration activity and economy, if we are going to intelligently redesign and rebuild corporate residential, industrial, and agricultural North America, we must hold onto the tool boxes. At this point, we are scarcely even able to evaluate the tool boxes. Most of us are just wondering whether they exist. So we need to learn to identify and save that which we can replace until we can demonstrate that we can replace it.

■ **Comment:** I want to throw out a challenge to everyone in this room who has a yard to start by restoring your yard to its native condition.

■ **Answer—Gerould Wilhelm:** Where would you start? If we have thrown away the tool boxes and thrown away places like the fen with a mean coefficient of conservatism of five, and all we have left are marshes with 75 species of weeds that do not form themselves, in a sense they are successionally emasculated. They cannot go any further than they have. They will just flop around in a state of synchronic retropede, releasing nutrients, boom and bust.

■ **Comment:** With my lack of knowledge of flora and fauna, I have gotten at least a coefficient that you in the field understand. I appreciate that and am glad you have ways of quantifying it. But in measuring success, we need to do more than just define success. We must actually measure success by obtaining the physical properties—the width, depth, period of inundation, temperature. For dirty water from the subdivision, we need to know how dirty it is to determine how to treat it. So in measuring success, we need to see chemical, channel morphology, and physical design parameters to meet previously set criteria.

■ **Answer—Gerould Wilhelm:** In a way, you have it right. A million gallons of water may fall in an acre. Water is not compressible—it is the real thing. In the Chicago region, a million gallons will evaporate if it falls into a bathtub that holds a million gallons.

At the time of European settlement, the Illinois River had virtually no discharge into the Mississippi during the growing season. Most rainwater remained in the Illinois watershed because of the connect—a macropore that connected between the surface and the crown. That was the root system structure of our native species.

You cannot build that with Kentucky bluegrass, red top, and clay—so what happens to a million gallons of water? That depends on the extent to which that kind of vegetation in a little watershed, a subdivision, or a corporate campus allows the water to flow into the wetland. We need to redesign landscapes to hold water where it falls so that the wetlands we build have a chance to be real.

■ **Comment:** So you have to quantify the landscape so that someone can build?

■ **Answer—Gerould Wilhelm:** I agree.

■ **Comment—Mary E. Kentula:** An important point was made about landscape. I am certain Gerould and I have a great overlap in the patterns shown by our data. The natural wetlands occurred in the same setting as the mitigation projects—in an urban setting with urban wetlands. Outside the urban boundary, we would get a different pattern. The urban wetland species, whether in a mitigation project or a natural wetland, tended to be facultative wet species. We were losing the obligate wet species, and everything else told us that the systems were drier.

The wetlands said something about the landscape and the processes that were supporting it. Both the mitigation project and a natural wetland was being affected by that surrounding landscape—they were not functioning in isolation. Would someone in a backyard have the energy to maintain a native system, given that landscape?

When we moved outside the urban landscape, we saw a different pattern. We picked up more obligate wet species and a higher percentage of natives. That pattern depended on where we were.

■ **Comment—Kim Herman:** Often we do not have that information. In working at the Michigan Department of Transportation, I was amazed at the creativity of the engineers. I want to take my hat off to them.

But I was on two recovery teams for two federal plants. Amassing all the information and haggling over what was important for the recovery of those species took two to three years. At least 15 percent of our state flora is threatened or endangered and the autecological requirements of those species are essentially unknown. In cases where we must do permitting and accept that plants or animals will be taken, we are often down to the wire and scarcely able to get one growing season's worth of information on these systems. That was the case at the airport. That is not unusual, but more the rule of thumb.

The engineers should know that the science is in its infancy. As frustrating as it may seem, that is the reality. We need to take opportunities to use restoration as an experiment, but at the same time, recognize that the answers will be a long time coming.

■ **Question:** With respect to the airport mitigation project, did Wayne County or Northwest Airlines ever commit to the five-year monitoring program suggested by the citizens' advisory committee? And secondly, do the recreational plans for the site interfere with the restoration or creation of the wetlands area? A variety of recreational plans were being considered.

■ **Answer—Kim Herman:** The wetland mitigation was a large one, maybe one of the largest in Michigan. I cannot answer your question directly, but a lot of public input went into that wetland.

I have a fundamental problem with designing wetlands that meet political needs without looking at and trying to replace the ecosystem. In this case, that is what happened. Having a management plan that will be adopted is good, but the resulting wetland design was essentially a compromise. The wetland may be pretty, but it will not be a true restoration.

A contingency states that if the criteria are not met, Wayne County must go back and look for a site, if one is left, to replace and protect it in perpetuity. We are waiting to see the outcome of the restoration mitigation.

■ **Comment—Dan Willard:** One thing this brought to my mind was the fact that we do not have much information on the functioning of seminatural systems. Almost all of our environmental sciences has been in response to some stress, so we know a great deal more about the stress systems than we do about the seminatural. Illinois, one of the great examples, has a biological survey that has tied together this information. It puts together the conditions under which certain kinds of communities exist. Wisconsin has a planned ecology lab.

But many states, like my own Indiana, have a sense of history that does not last 24 hours. We pay less attention than any state in the country—we are 52nd, counting Puerto Rico and Washington, D.C. We do not pay attention to our naturally occurring systems. If you wanted to study the natural ecology of the Mitchell Satyr butterfly, you would win a Golden Fleece Award from Senator Proxmire and would never get the resources. It takes years and it takes a lot. People question its value and costs.

We need to understand how 8.5 communities operate because in the future we will have fewer 8.5 communities to study and a lot of 1.2. In the greater Chicago area, you will even find some minuses on your scale.

I work for Lake Calumet region. One of the things that EPA can do in each of our areas is to look at functioning seminatural systems to serve as base lines and try to set long-term research programs. Pick these sites across the country to get a swarm of sites to compare against—that is the only way we can provide the kind of information the previous commenter will need. I do not believe you can recreate natural systems, but in some cases at least they can be restored. This kind of information is not available and useful. Every agency at every level needs to build up this information because we are losing our natural history.

■ **Comment—Mary E. Kentula:** I would like to second the motion and give an example of what we are working on the Wetland Research Program. Next summer, we will be in the field at 150 sites stratified by land use looking at the effects of land use, and in EPA jargon, the attainable quality in a land use.

To answer the question of how to get this done, we have a partnership with a university for a continuing education program for teachers. The teachers will be our field crews. We will train them and pay stipends to cover their expenses. The university will help them turn this into a program for their students, and show them how to bring it into the classroom to illustrate how science works and how to collect and use information. We had 44 applicants for 25 positions, and we are very excited about this.

We did another project with citizen volunteers. The data quality met the standards we set for the project. These people worry about doing it right, and therefore do it very well.

■ **Comment—Gerould Wilhelm:** We have to learn to restore the setting. We have become a culture entirely too comfortable living with dead things and too uncomfortable living with living things. The idea of having prairies denuded of species and flowers has become an anathema. We become annoyed when the leaves of the trees drop.

We cannot build a new economy while we divest the earth of its natural resources. We could, however, build a sustainable economy by reinventing natural resources, begin to comprehend these remnant communities if not natural, and learn to reemploy living systems back into the lands where we live, whether it be urban or agricultural. The rivers would begin to freshen, the fish would come back, the Gulf of Mexico would begin to revive, and we would have water back in the land. The key to this, of course, is learning to reestablish the setting.

■ **Comment—Kim Herman:** I failed to point out in the GIS map that our Natural Heritage Program Natural Features Inventory has the money to digitize the presettlement vegetation for the entire state. One of the pieces of information, of course, is the historical context. It is one point in time, but it would be a valuable tool in restoration for finding and helping to restore areas. And EPA was one entity that funded that. I imagine everybody now is beating at EPA's door because they want the same product. The ecologists in our program working with academia are quite excited about it.

■ **Comment—Bill Kruczynski:** The key word is reference wetland and the key to establishing whether or not a mitigation site is successful is what you compare it to. Mary has compared the created wetlands with the degraded urban wetlands and declared them a success. They were successful because you put back a degraded system—our standards in the restoration business should be higher than that.

■ **Answer—Mary E. Kentula:** I did not declare them anything because they did not come back to what the natural wetlands were, and they were too ecologically young to decide on the level of success. Remember, the groups were different from the natural wetlands. However, you raise an important question—the idea of reference. You need to hold people responsible for what is attainable, given the setting.

We made an important decision early in the studies that we would compare the projects to natural wetlands in the same settings and look at group statistics to see the range of possibilities. Then within the different settings, we might decide to hold them to a standard requiring that they give back the best that is possible, strive for the ones in the 90th percentile. But the question came out just as you said—we are in an urban setting and things are degraded. Critics would say that we are replacing trash with trash.

One reason this summer's study is stratified by land use is because right now we do not know how good or bad the system is. We only suspect it is degraded because it is in an urban setting, and we know something about ecosystems in an urban setting. The questions are about the status and how it compares to wetlands in a more natural setting. Are there land uses more kind to natural systems? If I want to preserve an area or have a mitigation project in an area that will have certain impacts, how do I buffer it from those impacts?

The key is the reference we choose to use and the standard. Given the setting, what is possible? And given that setting and comparing it to other settings, is the effort worthwhile? Would we call it a success?

■ **Comment—Bill Kruczynski:** One of the problems in the permitting system is that everyone is not doing things the same way. For example, I look at a wetland and say it is degraded based on a standard in my head that says it does not meet my ideal of the reference wetland. Each person's reference wetland is different because experiences are different.

We need to establish a series of geographic reference wetlands that people can look at on a video tape or card file. Then, when determining a wetland's significance and running wetlands through the section 404b(1) guidelines, my conclusion agrees with everyone else's conclusion. For example, where is this wetland on a scale of 0 to 10? I propose that reference wetland sites be established regionally—they would be very useful not only in restoration but also in the permitting business.

■ **Comment—Mary E. Kentula:** I agree. We also need to know what is out there—the range of variability—and not just the best, but what is actually happening. If we do not know those error bars around the average for natural wetlands, we cannot tie what is happening on a site back to the special sites that we picked as our goal and our reference.

■ **Comment—Kim Herman:** Regarding variability and permitting, I want to qualify my comments about wetland mitigation. Our DNR people in Michigan do the absolute best that they can and are some of the hardest working people I know. But regarding permitting for threatened plants, I was teased because it was one of the longest permits ever written for the endangered species program.

It has most of the criteria that have been mentioned. But the process is learn as you go; every time you try something, you add more to the permit the next time. The problem, then, is being perceived as inconsistent. You are, in fact, evolving these requirements as you get more information. A colleague said, "Oh, I'm glad you used the short form on this permit."

■ **Question:** As a highway engineer, I am somewhat intimidated by the setting and discussion, and I find myself trying to bridge the gap. Some environmental interests would like to discontinue all development. We do not have much say about that. But development is a reality, so we are trying to come out of it with as good a solution as possible.

I know we are on a learning curve with wetland mitigation and gaining on that curve. What do you see as the role of statewide wetland plans? Is there potential if wetland mitigation is not working so well? For example, you may have small acreage where mitigation does not seem to be that effective in an urbanized area. Yet another area of the state has a prime opportunity possibly within the existing watershed. Where do statewide wetland management plans fall into the picture?

■ **Comment—Kim Herman:** My understanding is that the DNR has EPA money to do a statewide comprehensive wetland plan for Michigan.

■ **Comment—Gerould Wilhelm:** It rains everywhere. We get 35 inches of rain over every square inch—on the top of a cane, the top of the Sears Tower, or the top of a wetland. Our challenge as engineers, as biologists, and as human beings is to think of water as okay. We are lucky that water will evaporate as it falls if we store it long enough in the land where it falls. If we divest ourselves of our responsibilities by shifting our wetland responsibilities off to some wetland bank, we are avoiding the issue and, in the long run, stunting the economy.

The challenge is how to redevelop a way of life, redevelop engineering, and redevelop landscapes that hold the water where it falls. That water is not compressible is an engineering fact.

The extent that we send it to the landscape dirty is the extent that the Gulf of Mexico is in trouble, that the Wabash is in trouble, and that the Mississippi is in trouble.

So the long-term goal should not be to have angina over the idea that we have wetland on our property but learn to like it—learn to develop a life style that acknowledges water as okay.

■ **Comment—John J. Berger:** I heard a policy issue implicit in the previous questioner's statement about development. He said that development is inevitable. My only quibble with that is that I would say that economic activity is inevitable. But it is *not* truly inevitable that we must continue developing the highest quality, near-pristine, or relatively undisturbed natural ecosystems.

If we exercise the impulse to engage in economic activity by expressing it in the redevelopment of already disturbed resources, we can satisfy this primal urge toward development by conducting useful and relatively nondestructive economic activity. And at the same time, we can save the undisturbed ecosystems.

It is a lot easier to destroy an ecosystem than to restore one. Any yahoo with a bulldozer can wipe out a pristine ecosystem, but it takes the best science to even approximate what was lost. So people committed to restoration need to also be committed to conservation and to putting a foot down when it comes to allowing further destruction of undisturbed resources.

■ **Comment:** Regarding the question about finding reference areas for geographic areas, I am a hydrologist with the U.S. Geological Survey. I work on the National Water Quality Assessment (NWQA) program. In using GIS, we overlaid different physical and land use characteristics and came up with areas that had similar geological land use. For most of those areas, the aquatic systems had no reference sites. This presents a problem about what is actually a reference site—most U.S. areas have no reference sites. ❑

# *CASE STUDY: Restoration Through Partnerships in Northwest Indiana*

## *CASE STUDY: Restoration Through Partnerships in Northwest Indiana*

# *Restoring the Grand Calumet: The Beauty and the Beast*

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The Remedial Action Plan (RAP) for the Grand Calumet River, Indiana Harbor Ship Canal, and Nearshore Lake Michigan Area of Concern by law must specify the steps required for "complete and systematic ecosystem restoration."[1] Ecological restoration of this globally unique ecosystem is a mammoth undertaking since it has been degraded by heavy industry for the past 100 years.[2] No individual can undertake such a task alone. Fortunately, the RAP has many partners to help restore the Grand Calumet Area of Concern (AOC).

This panel includes several of those partners, called "RAP participants." These individuals play key roles in restoring the Grand Calumet by helping their respective organizations focus resources on the ecological restoration of the AOC.

## The Challenge of Ecological Restoration

Before they speak, a brief introduction to the challenge of restoring the Grand Calumet is in order.

The Grand Calumet AOC is located in northern Lake County, Indiana, on the southern tip of Lake Michigan between the Indiana Dunes National Lakeshore (IDNL) on the east and Chicago on the west. It is a globally unique, groundwater-dependent ecosystem predominated by dune and swale ecology. The IDNL, where the science of ecology was invented, ranks third among all national parks in biodiversity of plant species. In presettlement times, the entire AOC shared this outstanding level of biodiversity, as shown by the remaining fragments of dune and swale and oak savanna within the AOC today.

The problems of the AOC ecosystem could be described in highly technical terms. We could describe the millions of cubic yards of contaminated sediments or the millions of gallons of oil floating on the groundwater. However, such technical descriptions of highly contaminated sites prompt some to discard damaged ecosystems rather than to work to restore them.

We have found that the key to ecological restoration in the Grand Calumet is motivating people to raise their sights about the possibilities of restoration. Only then are they willing to commit to the long-term work required for complete and systematic ecosystem restoration.

## The Lagoon—a Microcosm of the Challenge

Fortunately, a specific site within the AOC has the natural beauty to motivate such long-term commitment to ecological restoration: the Grand Calumet Lagoon. It is located at the headwaters of the Grand Calumet River in Gary on the eastern edge of the AOC and the extreme western edge of the IDNL.

The lagoon area is a microcosm of the challenges of ecological restoration within this groundwater-dependent ecosystem. The contamination of the groundwater ranges from slight to substantial.[3] That groundwater feeds the lagoon, the adjacent wetlands, and the interdunal ponds, flowing finally into Lake Michigan. Major hazardous waste sites are close by.

Since this lagoon is where the Grand Calumet River begins, its journey from the pristine conditions of Indiana Dunes National Lakeshore into the heavy industrial area of USX can be described in a more prosaic manner as the story of *Beauty and the Beast*.

## The Beauty is the Globally Unique Ecology

When a government official toured the lagoon area for the first time, he remarked, "This would be a nice place to spend my retirement." This area has retained high enough water quality to allow this groundwater-dependent ecosystem to support 150 wetlands, dune and swale ecology, and a relatively good, three-basin lagoon. Some coastal dunes are still intact.

The lagoon area provides much of the range of biodiversity that is impaired within the AOC because this lagoon area contains the Miller Woods, part of the IDNL. The lagoon area can be cherished for its worth by all, regardless of their scientific background or ecological understanding. This ecosystem is truly the Beauty of the Grand Calumet.

## The Beast is the Residue of Historical Contamination

However, moving from the eastern edge of the lagoon to its western edge and downstream into the heavy industrial riparian areas lining most of the Grand Calumet River, the lagoon area slowly degrades. Contamination sources affecting the lagoon include steel slag piles, urban and industrial runoff, sediment transport, residential septic effluents, air deposition, waste fills, and litter.

The Beast is the massive, if intermittent, industrial contamination that lines much of the river corridor.

In the fairy tale, the Beast must get the Beauty to kiss him before it is too late. The magical kiss will turn the Beast into a handsome prince so that everyone can live happily ever after. Such a complete transformation parallels that contemplated by the RAP for this ecosystem. How can we get the magical kiss of ecological restoration to transform the beast of historical contamination?

I believe the site of ecological restoration's magical kiss should begin at the Grand Calumet Lagoon. Here, RAP can test innovative restoration techniques that may be replicated farther down the river corridor. Here, potential RAP participants and the public can be inspired to believe that complete and systematic ecosystem restoration is worth the effort.

## How Complete Is Complete Restoration?

While the mandate of the RAP is to implement "complete and systematic ecosystem restoration," how complete can complete restoration be as a practical matter? How can you test the upper limits of restoration systematically over the entire range of degraded conditions found within the Grand Calumet?

The lagoon area will serve as a test site to answer many of these ecosystem-specific questions for the RAP.[4] Here the RAP can discover the practical, upper limits of ecological restoration and reconstruction within the AOC.

The International Joint Commission suggests that an iterative approach be used for restoring AOCs.[5] The Grand Calumet RAP must proceed by successive approximations because the practical upper limit of restoration is unknown for many sites in this ecosystem.

Although the actual presettlement conditions cannot be fully determined, the RAP must aim toward a significant increase in the biodiversity of native species. Problems such as incomplete data and the lack of a comprehensive scientific understanding of the interrelationships among all of the ecosystem's problems can be overcome by focusing on increasing the biodiversity of known native species. Working toward a significantly increased biodiversity with an interactive approach will allow restoration to show some progress in the immediate future, without precluding the higher levels of practical restoration.

## Visualizing the Results of Restoration

Restoring the ecology of this AOC requires visualizing the possibilities, despite the immediate problems. The RAP will use the lagoon as a specific restoration site to make ecological restoration of the entire AOC a more approachable goal. Seeing the results of the lagoon's ecological restoration will encourage RAP participants to strive toward the presettlement conditions to the maximum extent practical.

The panelists will speak about this ecological transformation of the Grand Calumet AOC and use the Grand Calumet Lagoon Area in their presentations to help bring ecological restoration issues into focus.

As persons interested in ecological restoration, we are all fairly optimistic about restoration. If I seem a bit more optimistic than most people about the chances for ecological restoration of the Grand Calumet Area of Concern, that is because I am a RAP coordinator. I have to be an optimist.

## Notes

1. According to the Great Lakes Water Quality Agreement as amended and the Great Lakes Critical Programs Act of 1990.
2. Stage I of the Remedial Action Plan for Grand Calumet River, Indiana Harbor Ship Canal and Nearshore Lake

Michigan Area of Concern. 1991. Indiana Department of Environmental Management, Gary, Indiana.

3. Doss, P.K. 1991. Physical and Chemical Dynamics of the Hydrogeologic System in Wetlands along the Southern Shore of Lake Michigan. Northern Illinois Univ., DeKalb, IL.

4. This is proposed in the Water Quality Component of Stage II RAP, which at the time of this writing is out for public comment.
5. See International Joint Commission documents discussing RAP development and implementation. □

*CASE STUDY: Restoration Through Partnerships in Northwest Indiana*

# *Citizen Activists: Key Partners in Ecological Restoration*

Charlotte Read
*Save the Dunes Council*
*Michigan City, Indiana*

In considering ecological restoration through partnerships in northwest Indiana, citizens and citizen groups are essential. The Save the Dunes Council has been a leader in creating the Indiana Dunes National Lakeshore and aware that preservation and restoration in this area are intertwined. Since the headwaters of the Grand Calumet River—known locally as the Marquette Park lagoons—are within the boundaries of the National Lakeshore, the council's concern with the Grand Calumet River is a natural outgrowth of our mission.

Many agencies with official responsibilities for the Grand Calumet River and the Indiana Dunes National Lakeshore are represented on today's panel. However, the impetus for creating the Indiana Dunes National Lakeshore and for cleanup of the Grand Calumet River started at the bottom with citizens—little initiative came from the top down. I'm proud to represent "the bottom" today—because without a bottom, you have nothing.

## A Forty-Year Focus

The Indiana Dunes National Lakeshore has been the focus of the Save the Dunes Council since 1952. The council took up the cause of saving the Dunes from earlier citizen movements, which started with Dr. Henry Chandler Cowles. Known as the founder of the science of North American plant ecology, Cowles began his pioneering studies at the Indiana Dunes at the turn of the century. His initial efforts to gain protection for the Indiana Dunes privately were unsuccessful. The first federal park proposal in 1916 recommended the Sand Dunes National Park and would have protected 25 miles of shoreline and 12,000 acres of duneland. While the Indiana Dunes National Lakeshore, created by Congress 50 years later in 1966, contains over 14,000 acres, it is a different area than that envisioned in 1916. Without citizens, the Indiana Dunes National Lakeshore would not have become law.

The organizations sharing this panel are essential partners in ecological restoration: the U.S. Fish and Wildlife Service, the Department of Natural Resources and its many offices, the National Park Service, and the Indiana Department of Environmental Management. Other potential partners are not here today: industry, the chambers of commerce, developers, local elected officials. These groups are either our partners in conflict or ultimately our partners in restoration.

## A Region of Contrasts

Northwest Indiana is now the largest steel producer in the United States. The Grand Calumet River, a tributary to Lake Michigan, no longer catches on fire but remains one of the nation's most polluted rivers. Lake County, our region's most industrialized county, experiences more toxic pollution in its air than do 20 states. Most of the area's wetlands have been filled with slag, are superfund sites, or have been ditched. Despite the polluted condition of the Grand Calumet River, little of it has been straightened. The Marquette Park lagoons are within in the Grand Calumet River Area of Concern and also within the boundaries of the Indiana Dunes National Lakeshore. The Indiana Dunes National Lakeshore includes 13 miles of Indiana's shoreline along lake Michigan, with a botanic diversity exceeded in only two other national park areas.

## Prosperity Without Poison

Pageants celebrating the Dunes were credited with helping to persuade the state of Indiana to protect a small part of the Indiana Dunes in a state park in 1926. Today citizens cannot rely on pageants to bring us restoration. Not only should ecological restoration take place, but it *must* take place. Petitions and pickets may help. Politics are extremely important. The ecological degradation that has been allowed to happen here creates a moral imperative that ecological restoration take place here.

But protest is fast becoming the tool of citizens. Many state and federal agency personnel hate to come to northwest Indiana because we want clean up, and we want it NOW. In order to underscore what many citizen groups in northwest Indiana want, we have endorsed the slogan, "Prosperity Without Poison." We want ecological restoration on the land, in the air, and in the water.

We have an area of incredible beauty, incredible pollution, incredible dissatisfaction, and incredible opportunity. In northwest Indiana, restoration of both the physical and the ambient environment is not only an absolute for ecological health, it is essential for economic health. Using the analogy of the Grand Calumet River as a beast—to kiss the beast and turn it into a handsome prince, we will need a lot of people willing to pucker up. ❑

# CASE STUDY: Restoration Through Partnerships in Northwest Indiana

# Natural Resource Trustee Cooperation

Wayne Faatz
*Indiana Department of Natural Resources*
*Indianapolis, Indiana*

As the contaminant program manager for the Department of Natural Resources, I am often called upon to describe my job. It is a very complicated job listing. Some biologists' work has glitch and glitter—like working with the National Heritage Program. I, on the other hand, am down in the sewers with the rats. But it is a vital function.

This presentation is about restoration through partnerships, specifically about the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Clean Water Act. How does it work and how do we do this?

## Recognize Key Players

First, you must recognize the key players and know the federal and state trustees. You must know your partners and have a good working relationship with them. Avoid a closed mindset—this is mine, that is yours, or that is the EPA's authority, not yours. This can cause all kinds of trouble—for example, endangered species. The endangered bald eagle is a federal specie. But it is a state-listed specie and it eats state fish. But with a parochial attitude, you may as well tell your eagle to go somewhere else.

This is how animosity starts. It also has the unfortunate drawback of lost information and expertise. Sometimes states or agencies working together can accomplish a lot more than one agency alone, regardless of how large or small.

Assume a biological basis when you attack these problems. For example, in a CERCLA meeting, do not think in terms of the federal share being a certain amount of dollars and the state share a certain amount. Instead, first meet with your trustees and your working groups. Think about one settlement, one ecosystem, one parcel—not about dividing up the area like a piece of pie. Either you settle the whole pie—all the biological criteria—or you settle nothing. This is a very effective working advantage. It keeps the potentially responsible parties from dividing and conquering.

## Relying on Imperfect Data

Dr. Dennis King talked about three layers—absolute science, expert science or opinion, and post science. When negotiating, you are dealing on the outer edge with very little science to go on. You must rely on a scientific guess—what you intuitively feel. You may also be under time constraints—you may need to settle this situation in the next six hours. But you will not settle it in the next six years without the data base. Without time to collect the data, you must learn to go with what you have. Through partnerships with various groups, you can collect an amazing wealth of data on very short notice.

Another key point is to educate your lawyers. In negotiations, you have your lawyers and they have theirs, but you are always outnumbered. It is not uncommon to go in with three lawyers compared to their nine. Lawyers are operating under a different philosophy—the letter of the law. A critical factor is finding a lawyer that understands and believes in what you are doing. You need to trust the people you work with, remain flexible, and be willing to compromise.

You need to be willing to shift plans. You may think of every contingency for plan A, but always have a plan B. You need to be prepared to keep shifting because these situations are dynamic. We live in an imperfect world and you are dealing with imperfect science. You need to take risks, which require someone to make a decision. Things can drag. Be innovative. Do not be afraid to try new ideas or take new approaches. The worst that can happen is that the plan does not work. You need to stay one step ahead. The other side is smart, too—the better they can anticipate your moves, the better they can mount a defense against you.

## Think Positive

Take a positive approach. Facing difficulties and obstacles is the nature of the beast. Do not think of the reasons why it cannot be done or why it will be hard to do or why you cannot do it. Figure out what it will take to get over the hump.

One of my favorite lines is, "We haven't got the money." With $10 million, you can do everything, but sometimes you might only get $1 million. With innovation and flexibility, you still can do a lot. For example, a case called "Fisher-Calo" was one of our first settlements. The Fish and Wildlife Service took the lead. Although the federal interests were limited, with the trustees' acquiescence, we agreed to join in. We also agreed beforehand that we would not fight over money—the important issue was the restoration or mitigation of the property. In this case, the federal government's share was $20,000 and the state's $200,000. But the plan we developed provided that all the money would go toward the same thing.

The scientific data was less than perfect—in fact, it was paper thin—but we presented it, fought hard, and got a settlement. Initially, we asked for $300,000. The other side countered with $100,000, challenging us to justify our position with data. Our situation was whether to jeopardize $100,000 in hand or make a counter offer and risk everything.

It all hinged on the data. So I phoned the Fish and Wildlife property manager, a 15-year veteran of the property adjacent to Fisher-Calo. One phone call provided historical data, animal and endangered species distribution, and economic and land use history. This new data resulted in a $200,000 offer. At first, the lawyers did not understand that the natural resources damages were legitimate. When the potentially responsible parties made an offer, our lawyer classified it as generous, and refused to carry negotiations any further. We had to fight with our own lawyer.

In a current case, our own lawyers would not recognize our authority, and we were thrown out of a meeting. However, the second time we went back, we were much better prepared. In addition, the natural resources damages became real and the potentially responsible parties finally understood that they had to face the issue.

## Compromise is Golden

You must remain flexible and be willing to compromise. Settlement negotiations are like a poker game—play the cards and throw in the chips. Sometimes you win, but you also must be prepared to lose.

In the case of Fisher-Calo, a $200,000 settlement was not bad, but not a lot of money, either. Suppose we leveraged the $200,000 by borrowing $2 million from the Division of Fish and Wildlife—essentially borrowing our own money? Since we are entitled to federal reimbursement at 75 percent, we would have $1.5. Adding our $200,000, we would then have $1.7 million. Then all we would need is $300,000 to buy 2,000 acres—worth approximately $2 million. Therefore, we have just leveraged our original $200,000, actually spent $300,000, and ended up with $2 million worth of land. That is innovation.

You can also try different regulations. In the past, we might have sent a violator several notices of violations. The violator is generally unconcerned—after all, he/she has received these before and nothing happened then, so nothing will happen now. But during the next inspection, we charged the violator under a different environmental law—a class D felony requiring jail and a $5,000 fine. He is willing to talk to us now.

You need to keep your partnership going, know your key players, and be willing to cooperate. And as we work in northwest Indiana, we will be including more and more players in our restoration efforts. ❑

*CASE STUDY: Restoration Through Partnerships in Northwest Indiana*

# *Cooperation on Natural Resource Damage Assessments (NRDA) for Habitat Restoration*

Dan Sparks
*U.S. Fish and Wildlife Service*
*Bloomington, Indiana*

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) mandated that EPA use regulations to get hazardous waste sites cleaned. CERCLA and the Oil Pollution Act also has a little-known provision requiring restoration and compensation for natural resource injuries at these sites. Wayne Faatz discussed the importance of trustees cooperating for the resource — the regulations even call for it. Yet amazingly, many of our sister states have not figured out how to make the most of their limited resources and manpower.

Together with Indiana Department of Environmental Management and the Department of Natural Resources, we have reached some eight natural resource settlements that EPA and Environmental Management have collectively tried to remediate. Once the regulatory cleanup is complete, our goal is to restore, replace, or compensate for the natural resource losses.

## Huggable Natural Resources and the Regulatory/Legal Process

I am somewhat biased about natural resources. I talk about the fins and furries, the huggable natural resources. Earlier, several speakers talked about protecting high value ecological areas through the 404 permit process. Permitting can be avoided and possibly managed; but a spill or a release of hazardous substance can impact these areas. They happen and will likely continue to happen, but we hope on a smaller scale in the future.

When science meshes with the legal arena, the process is incredibly bureaucratic and can be pretty frightful. Many of today's regulatory processes are based on numerical standards for various pollutants as found in 40 CFR and other regulations. They are not necessarily based on critter or ecosystem effects—and a lot of that science still remains to be figured out.

## Include the Ecosystem

Another problem for trustees and trustee resources is that a regulatory cleanup typically draws a boundary around the problem area but not around the fully effected ecosystem area. Every situation is different—our representation changes, their representation changes, and frequently the ecosystem changes.

In restoration, you start with "X" percent ecological value. Once you have an event—a spill or perhaps Solvent Recycling decides to setup shop in Yourtown, U.S.A., and starts dumping wastes—obviously, resource values go down. If you create an attractive nuisance that not only destroys everything, but also sucks in additional critters and kills them off as well, natural resource losses can actuality go below zero.

When we talk about habitat quality, we are also talking about all components of habitat quality. You can build a physically restored, high quality wetland with chemical quality so bad that it is an actual detriment to the wildlife you are trying to rejuvenate and protect. The process is only as good as the joint strength of the partners. For example, we could not get off square one if we did not have a good working relationship. Our partners have biologists out in the field. We sometimes have good leads into some of these legal processes. We share good information. All this is tremendously beneficial and draws on all the experts.

## Early Coordination Saves Land

Regarding Fisher-Calo, I would like to add several points. Yes, the U.S. Fish and Wildlife Service did get $20,000 as opposed to Indiana Department of Natural Resources' $200,000. But right before the NRDA settlement by early coordination with EPA's remedial project manager, we were able to change a minor detail and, in essence, save 277 acres of pristine wetlands of all types—emergent, scrub shrub, and forested wetlands. So the willingness of the remedial project manager to deal with the ecologist avoided a tremendous additional injury that remediation could have caused. To EPA's credit, the excellent working relationship protected those habitats.

Also, $220,000 can buy a lot of marginal agricultural land (degraded wetlands). We can do a lot of restoration for that kind of money. Considering the fact that Indiana has lost 87 percent of its wetlands, $220,000 goes a long way.

In the case of a spill, you are not always going to get back to where you started. Just talk to my peers in Alaska about restoring Prince William Sound. You could put some of the pieces back and in a few million years the Arctic microbes will take care of the rest. We also must be concerned about remediation techniques. The beaches that were not steam-cleaned are actually recovering faster because the microbial layers were not destroyed. The steamed-cleaned beaches were sterilized. So we need to look at both sides of the coin.

## Citizens are Best Source

Grand Calumet, Indiana Harbor, and Marquette Park lagoons are my favorite areas. This area has a tiny 47-acre nature preserve with the highest concentration of state-listed threatened and endangered species. It sits on Lake Michigan's southern end, a tremendous migratory pathway for birds. While the area is phenomenal, the average person looks at it in a different light. The area has value but lacks a lot of hard science on the effects of some local problems and issues our partners were trying to rectify. The best source of anecdotal information on the effects of some pollutants and habitat destruction is by far local, concerned citizens. Some elder citizens who knew the area in the '40s and '50s tell mind-boggling stories of the river's incredible diversity.

Working together now and in the coming months and years, we will try to fill some of these science gaps, and through effective studies find out what is actually happening. In the basin, we are also hoping for a major settlement on which we have worked for nearly three years and EPA has been involved with for over 14 years.* These Natural Resource Damage Assessment settlements are slow processes.

At some sites, paving a contaminated wetland to remove the problem may be better because the technology is just not available to restore the site. We need to do the best we can with what we have and learn from our mistakes. Getting something through the NRDA process is a lot better than getting nothing. ❑

* As this proceedings goes to press, the Midco I and Midco II natural resource damage settlement has been finalized. This settlement involved the purchase and transfer to IDNR Division of Nature Preserves of the 253-acre Bongi Cartage tract. This site is home to many state and federal endangered species and will be added to the 47-acre Clark and Pine Nature Preserve. The settling parties have also provided funding for additional habitat restoration on the Bongi tract.

## CASE STUDY: *Restoration Through Partnerships in Northwest Indiana*

# *Natural Resource Restoration at Indiana Dunes National Lakeshore*

Richard Whitman
*National Park Service*
*Porter, Indiana*

In my first week at the National Park Service about four years ago, I was asked my opinion on an industrial concern seeking clean closure.

After 10 years of academia, working in a narrow field, and seeing my colleagues at scientific meetings once a year, I recommended calling in a geologist or a civil engineer. At the time, I questioned why we were being called—it was not directly a National Park problem. I discovered that we, indeed, had an interest in what was happening. Moreover, I soon found out that not only Fish and Wildlife had an interest, but also EPA, Department of Environmental Management, Department of Natural Resources, the Corps of Engineers, and interest groups like Save the Dunes Council—even the city of Portage had an interest. After three months on the job, I was freely giving advice and direction to environmental problems.

## Everyone's Problem

Environmental problems are not just National Park Service problems; they are everyone's problems. This particular situation was not an adversarial relationship with the industrial concern; it was something that concerned us all and a real case example of how we can go forward with minimal friction and litigation to resolve a problem. This case is still ongoing and is becoming more and more interesting.

We must work as a community. None of us—agency or individual—has the experience or expertise to work alone. We are dealing with complex problems. We share the responsibilities, more so in northwest Indiana than in any other place I can think of. We do not have the economic or the political support to do it alone, so we must form partnerships.

Restoration at Indiana Dunes National Lakeshore covers a wide area and includes many activities (see Fig.1). The National Park Service started in 1916 with the Organic Act. The Indiana Dunes area was the third national park recommended by Congress. World War I got us off track, and we did not get on track again until 50 years later. Those 50 years were nearly too late for the Indiana Dunes.

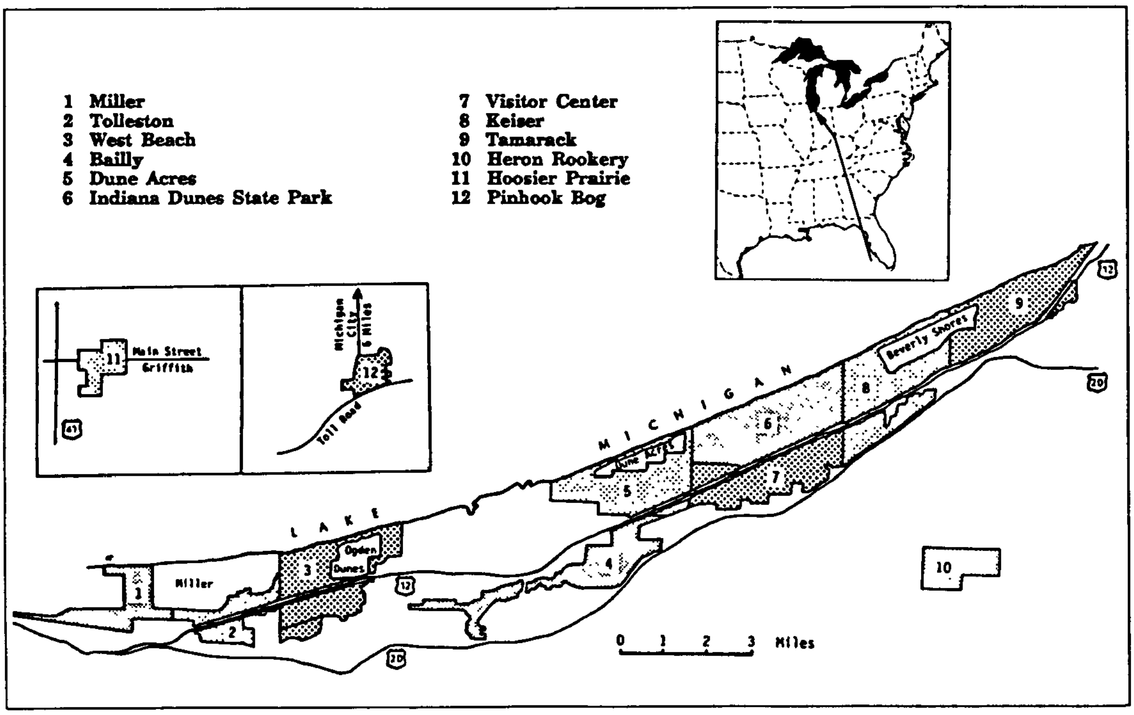
People like Charlotte Read helped build that park. My boss tells the story of a park tour he and Charlotte took. He commented about the irregular and unusual configuration of the park's boundary line. "Do you realize that I helped draw those boundaries, and it was not easy," Charlotte responded. This is a park by the people—possibly more so than any national park or federal area in the country. It was built, lobbied for, and fought over for decades before it finally was established in 1966.

The National Park Service has a dual mandate outlined by the Organic Act. It provides for the protection of resources and for the enjoyment of present and future generations. As far as natural resources, we at Indiana Dunes have a third mandate—resource restoration. When Congress finally gave us the Dunes, it gave us damaged goods. We need to invest far more than our generation can provide to restore it as best we can to its original habitat.

## Restoration's Patron Saints

We have many patron saints at Indiana Dunes. An important one is Senator Paul Douglas, who fought hard and used his political might to establish the Dunes. Many of the great heroes of the National Park came from Chicago, including

**Figure 1.—Management areas of Indiana Dunes National Lakeshore.**




Senator Douglas. One of Senator Douglas' famous quotes was, "When I was young, I wanted to save the world. In my middle years, I would've been content to save my country. Now all I want to do is save the Dunes."

Another patron saint is Henry Cowles. He was a pioneering ecologist and co-founder of the laws of succession. He recognized the process of succession and the Dunes' magnificent floral diversity and biological significance. He laid the foundation for modern ecology.

A second individual from Chicago, Victor Shelford, was recently the subject of a biography. The book suggests that he is the "Father of Animal Ecology." Most of his work—the development of Shelford's Law of Tolerance and Principles of Eutrophication were developed at Indiana Dunes. These two people in the northwest Indiana-Chicago land area helped lay the foundations of ecology and environmental science. So we do have a legacy in history.

Indiana Dunes has 15 miles of beaches—the largest access to Lake Michigan in Indiana. It shares jurisdiction with a number of communities, industries, and other entities. We have already alluded to the area's biodiversity. Its third largest plant diversity in the nation makes it remarkably species rich. The Dunes' perturbations and stresses also make it remarkable. It probably is the most threatened park in the country with every conceivable problem of any park in the National Park Service, with the exception of the Everglades.

## All of the Above

When I go to Shenandoah and hear about air quality, or to the Grand Canyon and hear about visibility problems, or about oil and other problems in Alaskan parks, or the visitor problems at Yellowstone, I think, "We've got a little of all of these." In fact, if you are looking for an outdoor laboratory or experiment, come to the Indiana Dunes—we have it for you. We have two fossil fuel plants within the Dunes, many sewage treatment plants, three steel mills, and a whole variety of interspersed industrial-municipal complexes within the park itself.

At Indiana Dunes, we are trying to restore black oak savannas by razing home sites that we bought up, leased out, and took down. (On some, we removed sod and exotic grasses.) Our plant ecologist is trying different treatments to determine the best way to restore the land to a target vegetation and habitat.

When I got to the Indiana Dunes, I was surprised that we did not have a prescription to restore black oak savanna or other habitats. I assumed a basic strategy was already in place. But, in fact, we are just at the beginning of understanding how to bring them back. Among the different treatments we are using are herbicide, physical removal, sod removal/scalping, and fire.

## A Mixed Blessing

Fire is a bit problematic in the Dunes. We use it to maintain the system and to restore critical habitats, especially with the Karner blue butterfly, an endangered species. We have the second largest population of the Karner blue butterfly in the nation. Just listed this year as an endangered species, it has incredible requirements. The paradox is that at Indiana Dunes the Karner needs black oak savanna which needs fire—but the same fire kills the larvae. So we just cannot burn an area and hope that the Karner will come back. If we do not burn in a controlled fashion, we will take the population out completely. Because this problem is incredibly complex, we have our new animal ecologists looking at it.

We also have exotics like purple loosestrife. With loosestrife, we are cooperating with the Department of Natural Resources and the University of Wisconsin. We are trying to understand the basic biology and inventory to get a handle on its control. Other exotics include the zebra mussel. It started invading in 1990 and now we have over 50,000 per square meter on higher solid substrates. We have just begun to realize its impact. The first year I looked for funding to support it, no one knew what a zebra mussel was. Now they know. We are really concerned about places like St. Croix, which has the perfect habitat for it, several endangered mussels, and a whole variety of other mollusks that will be affected.

These are just a few of the many exotic plants and animals with which we deal. We do weekly continuous water quality monitoring of well sites, stream sites, and lake sites and try to respond to perturbations that we witness.

We have sacrificed areas like Mount Baldy, allowing visitors to enjoy and trample. This is a living dune, and it probably would not have much vegetation on its face anyway. But we also have dunal plants—for example, the dune thistle, a federal threatened species. We try to direct people away by putting in boardwalk fenced areas and maintain a habitat that the dune thistle needs to survive.

## Much to Learn

At Indiana Dunes, we have slack water areas called pannes—they are ecologically unknown. We understand a little bit about their water chemistry and something about their vegetation; but as for the rest of the biology, we know little. Part of our effort is to understand the baseline. We are putting together cooperatives with Dan Sparks and probably the Department of Natural Resources to look at the great blue heron, PCBs, and what problems are created. We need to look at restoring the Little Calumet River to its natural flow and biological status.

The Great Marsh is a valuable natural resource. Formerly going from Michigan City to Gary—about 20 miles—the marsh is now less than three miles wide. Some 3,000 acres were heavily dredged and filled to accommodate municipal and agricultural development. We need to study three creeks—Derby Ditch, Dunes Creek, and Kintzle Ditch—with the idea of deditching at least some of them and trying to restore the Great Marsh. This is an incredible problem, but it is an incredible resource.

Derby Ditch is a point source that floods our beach with bacteria and introduces iron, tannic acids, and many other pollutants. It is a big eyesore. We would like to close it, but we do not have the political or legal muscle. We cannot do it without partnerships.

Oftentimes a beach on the Great Lakes will appear to be just sterile sand around the river. But most areas have some organisms taking advantage of the resource. For example, a whole community that was poorly understood and undiscovered until three or four years ago is the interstitial melofauna. It is obligate to groundwater. So now biologists have an indicator community for groundwater. We are still discovering communities and animals. We need to start at the bottom in more ways than one.

## A Success Story

One of our great restoration success stories was a salt storage facility by the Department of Transportation at Pinhook Bog. Through several years of study by a doctoral student, we were able to document the salt's impact on this precious resource, a national landmark. We bought the property from the Transportation Department and removed the facility. After 12 years, we are continuing to monitor the slow recovery of the bog species.

We have used Geographic Information Systems (GIS) as well. While we know we cannot bring back the buffalo, we have looked at reintroducing the bobcat. That would obviously include the Department of Natural Resources, the local community, and the Fish and Wildlife Service. We have mapped the potential bobcat habitat, but the bobcat probably cannot locate far enough away from human disturbances to successfully breed at Indiana Dunes. So bringing back the bobcat is unlikely. But we are getting some coyotes back and we have other wildlife—some not so desirable.

The deer, for example, have become a nuisance as they are in Chicago and Brown County. We are working with the state to put together programs for comparative status. We need to develop some exclosure studies. Although we know the deer are affecting rare plants, we need documentation before we can take action. These animals and others carry diseases. We are cooperating with Ball State and the Department of Natural Resources to document the deer tick and trying to monitor Lyme's disease frequency.

## Problematic Cuddlies

Other cute little cuddlies like the racoon have become a problem, especially when people feed them. We have a fragmented habitat that encourages their overpopulation. Not only do they have problems like distemper and rabies, but they likely have a tremendous impact on our nest and bird populations. We are planning to document the problem to justify control.

The black oak savanna at the Dunes is the target of restoration efforts where an incredible floral diversity exists. The Marquette Lagoons are just north of the Miller Woods savanna. We understand more about these interdunal ponds than in any other aquatic park area. We not only understand the hydrology, the water quality, and the land use, but we also understand the historical context of research going back to the turn of the century. We have some of the oldest baseline data in the world.

One of our largest interdunal ponds, Long Lake, had a fish kill in 1990. I wrote it up as winter kill. But recent data shows toxicant levels high enough to cause stress on the environment; and it needs to be looked at more closely. Because this pond has no point or nonpoint source, most of its input probably comes from atmospheric deposition. If that is true, then most of our waters have the exposure. Other research has already shown predominantly atmospheric deposition of heavy metals and organics.

## The Great Social Experiment

The Indiana Dunes is a great social experiment to see whether humans and the environment can coexist—and the jury is still out. Many generations must pass to see the success or failure of the Dunes' experience. This experiment reminds me of Ben Franklin's comment at the signing of the Declaration of Independence. He looked at the sun and said he was not sure whether it was rising or setting. I ask the same question for the natural areas of the country—is the sun rising or setting? The answer lies within us all. ❑

## CASE STUDY: Restoration Through Partnerships in Northwest Indiana

# General Panel Discussion


Joseph D. Thomas
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*Gary, Indiana*

Charlotte Read
*Save the Dunes Council*
*Michigan City, Indiana*

Wayne Faatz
*Indiana Department of Natural Resources*
*Indianapolis, Indiana*

Dan Sparks
*U.S. Fish and Wildlife Service*
*Bloomington, Indiana*

Richard Whitman
*National Park Service*
*Porter, Indiana*


**Question:** Would it not have been a tremendous advantage to have had a central natural resources data collection? What are you doing to make sure that the information and anecdotes are available for the next war? This is surely not the last one in that area or the region.

■ **Answer—Wayne Faatz:** This is a pet peeve of mine. I go to many meetings where we need to get GIS data to the public. What does getting it to the public mean? Does it mean putting it into a library where no one ever sees it?

The data is out there, but that is a problem. EPA, the state, and Fish and Wildlife Service all have tons of data. The trick is to centralize the data base; the hard part is putting GIS data into a practical application. Those who generate the GIS data say it has a variety of uses. But they lack the expertise or the partnerships to provide the GIS data in a useable form.

The cost of centralizing data is enormous. Everyone enjoys collecting data, but the down time involved in entering it into the system is horrendous. And who absorbs the expense? I, too, would like to see centralized data. Indiana very seldom has an ecological history of over 24 hours—sometimes it is even shorter than that. Often good data is out there but we do not even know it exists. The information transfer system is also a real problem.

■ **Comment:** We are getting started. This summer, we are undertaking a major effort to get a handle on what is going on beyond just an anecdotal situation. We have about eight different studies, although they are not totally in-depth. We hope to have enough of the right kind of information to get started. Some of these studies will take a long time—five, six, 10 years. But we need to start somewhere and start now. It is a long drawn-out process, but at least now we have some resources to begin.

■ **Comment:** Steve Gorinson is heading up an interagency group looking specifically at that problem. One problem is that we have computers and GIS systems that do not even talk to each other, much less share data—and that is just at the federal level. The best and most comprehensive data out there is locked up behind library walls and on shelves—in dissertation and theses. We rarely look at that data when we need historical information.

■ **Comment:** I was recently with the Illinois Department of Energy and Natural Resources at the U.S. Geological Survey and now I'm in private practice. I was one of the original principal investigators in developing the critical transassessment project in Illinois. The project's focus and mission was to bring in data sets to look at environmental conditions throughout the state. Trying to assemble the data— trying to get it released from various agencies—was the largest stumbling block. In fact, it is still a problem. Data protocols needed to be established between agencies to allow the data to be shared. Much of Illinois data were on three-by-five cards stored in the third sub-basement. The problem and expense was organizing this and pulling it together into a form that can be easily accessed by all the people who need it. ❑

# *PANEL: Incentives for Restoration*

*PANEL: Incentives for Restoration*

# *There's More to Restoration Opportunities than Mitigation*

David H. Behm

*Minnesota Board of Water and Soil Resources*
*St. Paul, Minnesota*

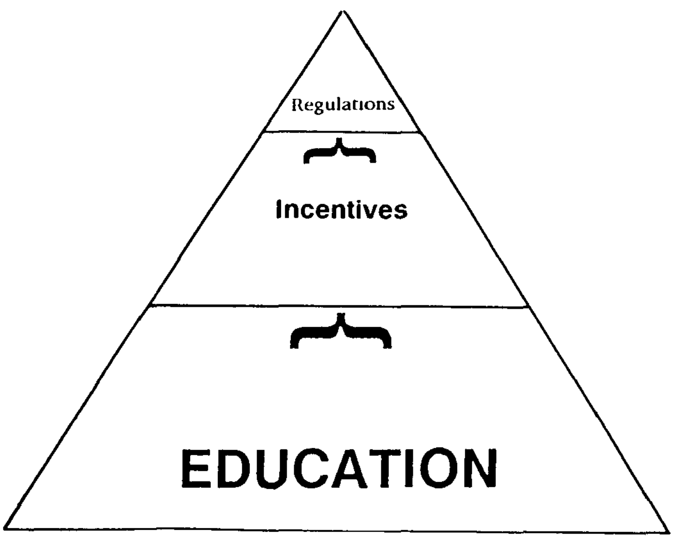
Remove the whole concept of a regulatory framework from your mind. Just imagine that people out there, voluntarily and with the right incentive, are willing to come forward and do some ecological restoration. For the moment, just believe that myth.

This situation has nothing to do with regulation—regulation is not driving the desire to participate in ecological restoration. Many people living on the landscape participate in voluntary programs and have made voluntary efforts.

## The Programmatic Pyramid

What motivates people to do things? A simple, conceptual model—the programmatic pyramid (see Fig. 1)—will illustrate. This model has three components—education, incentive, and regulation. The whole of the pyramid represents all those activities that resource managers use in their collective attempts to influence the resource management decisions and actions of private landowners. The bottom of the pyramid is the education component. This illustration is of a relative effectiveness scale, not an exact number. It represents the relative effectiveness of soley an education-based approach to affect resource management decisions. Most people will change their behavior and do the right thing if presented with convincing information in an appropriate educational context.

**Figure 1.—The Programmatic Pyramid.**




Information, different from education, is not terribly convincing unless put in a learning context. Most agencies have done a poor job of educating people. We find it easy to put out a brochure, but we tend not to follow up or put the information in context. If we would do a better job of education, we would see many more people doing the right thing.

## Benefits—Public and Private

Part of the education process is to learn that doing these things creates some public benefits, such as groundwater protection. It also creates private benefits—economic viability of a farm, for example. The public benefit, of course, is that groundwater does not just benefit one person, but is an aquifer that serves many. The soil being conserved and the nutrients being properly managed not only help the individual's pocketbook, but doing the right thing prevents contamination of the groundwater—a public benefit.

Some individuals will actually stop harmful activities, or more likely modify them, and do the right thing simply from education alone. Others, though, will agree and understand, but their individual private costs to modify this behavior prevents them from being able to provide public benefits. That is where incentives come into play—the next tier of the pyramid. The public expects these benefits and is willing to pay for some of the public benefits that private interests simply cannot afford to provide. In matching incentives with education, most individuals will be convinced to change their activities to do the right thing.

## Leveraging the Program

Of course, we do not have the luxury to pay for every conceivable education and incentive program. So we need to leverage as many individuals as we can through volunteer activities. In this way, we can reach large masses of people who control and influence the landscape through voluntary programs.

Regulation sits atop the pyramid. It illustrates the ability to effectively leverage the large majority of individuals affected by voluntary activities contained in the lower components. Regulation, on its own, is the least effective factor affecting the smallest group of people. Good regulation must be focused. If your aim is to regulate the farming community, you have undertaken a broad task. If, however, you wish to address sugar beet farmers near the Red River in Minnesota, you will likely have more success in fine tuning the regulations to fit the particular individual and the type of farming operation.

## Regulation—the Last Effort

Not only should regulation be focused, but it is placed at the top of the pyramid because it should be the last initiative employed, and only after sound education and incentives programs are in place. If you have done an appropriate job through education and with incentives to bring volunteers out and do the right thing, regulation may not be needed. Most people will discontinue activity simply for private gain once they are shown that their actions are not in the public interest.

Obviously, this is a gross over simplification, but that is the nature of models. Regulations certainly have a place, and presentations at this symposium have shared the regulatory framework. Most of us have talked about restoration, particularly wetland restoration and creation, from the standpoint of what we are going to achieve through mitigation. Mitigation, by its very nature, is tied to a regulatory framework.

I heard here that the federal 404 permits—the principal means of mitigation activities in this multi-state region—will achieve hundreds of acres of wetland restoration. Yet, Charlie Wooley from the Fish and Wildlife Service mentioned that 40,000 acres of wetland restoration are in roughly in the same area from one program. Just look at the difference in magnitude of scale between these approaches.

In the Reinvest In Minnesota (RIM) reserve conservation easement program that I previously presented, we have achieved about 9,000 acres of wetland and adjacent upland restorations. This is for only one state and one program. The magnitude of opportunity for voluntary efforts is different from the regulatory framework. This alone should spur you to try a voluntary framework—that is the greatest opportunity to make a substantial gain in ecological restorations on a broad scale.

## Cost-Effective Restoration

This is not to say that you should back away from regulation. The technical challenges ahead demand that you use regulation to turn failure into success. But most of the restoration is relatively easy and inexpensive. For example, the cost of easement, program administration, and practices for RIM Reserve is about $1,250 an acre, including all the costs for a wetland restoration easement, and with an average size of 33 acres.

A lot of opportunities exist out there. Collectively and as individuals, you can make a much greater contribution to ecological restoration from the voluntary side than you will ever be able to achieve through the regulatory side. While I acknowledge and understand the need for a regulatory framework, mitigation, and the high expectations that we have for mitigation, many more opportunities await you "on the other side." ❑

PANEL: *Incentives for Restoration*

# *Incentives on Private Lands*

Don Butz
*USDA Soil Conservation Service*
*Washington, D.C.*

Much discussion about wetland restoration throughout the United States in the past years has existed in a void—we had no true guidance on how to restore wetlands. However in the past two years, EPA, Corp of Engineers, the Soil Conservation Service (SCS), Extension Service, and others have developed a wetland restoration chapter to add to the Soil Conservation Service's engineering field handbook. It identifies the procedure that should be followed and the types of practices required to restore the hydrology for restoration, creation, and enhancement of wetlands.

We also developed a training course on wetland restoration, which SCS and Fish and Wildlife have given in several U.S. locations. A number of state agencies involved in wetland restoration have attended these training sessions, which have been well accepted. In fact, the demand for guidance is greater than our ability to meet it. Some good efforts are going on throughout the United States—team efforts as opposed to one individual agency.

## Benefiting Society

Two incentive programs worth mentioning are the Conservation Reserve Program (CRP) and the Wetlands Reserve Program. Both programs have and will provide many benefits to society. Congress initially established the Conservation Reserved Program to reduce agricultural surpluses—wheat, corn, rice, and similar crops—reduce erosion, improve water quality, and develop wildlife habitat. Farmers receive an annual 10-year rental payment to stop producing commodity crops on the land and establish a vegetative cover of grass, trees, or wildlife habitat. Farmers also receive 50 percent of the cost of establishing the vegetation needed to protect the land.

Currently, we have approximately 36.5 million acres in the program, consisting very roughly of 2.5 million acres of trees and 34 million acres of vegetation. The vegetation includes native or warm season grasses and nearly 26 million acres of cool season, or introduced, grasses such as timothy, orchid grass, broom grass, and other similar types, many of which have been seeded with legumes. Nearly 300,000 acres of wetlands have been brought into the program during a short period of time.

In many places, Fish and Wildlife Service has assisted with restoration of these wetlands. The remaining acres consist of things such as filter strips along the streams, lakes, and rivers; well-head protection; windbreaks; grass waterways; and wildlife habitat development vegetation.

This program has provided substantial benefits above and beyond its overall objective. We hear every day that wildlife improvement has been tremendous. The number of pheasants, deer, and other wildlife has increased throughout the United States. But the first 10-year contract will terminate in September 1995. The real question is this: what will happen when the contracts terminate? Will they convert back to crop land? What will Congress do? Will it extend the contracts? Will Congress offer an easement program or purchase the land? We could speculate, but at this point we really do not know what Congress will do. A number of task forces are working on the problem, including a USDA task force, which is currently looking at life after CRP and trying to make sure that the program's gains are maintained.

## WRP—New and Exciting

The rest of this presentation will focus on the new and exciting USDA Wetlands Reserve Program (WRP). In 1990, Congress passed the Food Agricultural Conservation Trade Act authorizing the program. A team—including USDA, EPA, Fish and Wildlife Service, and nongovernmental groups—established the program's rules and regulations.

WRP is a voluntary program offering agricultural landowners a chance to receive payment for restoring wetlands on their properties.

The program purchases conservation easements from participating landowners, provides 75 percent cost share payments for wetland restoration, and is authorized to restore up to 1 million acres through 1995.

The main thrust of the program is to restore wetlands. The program includes minimal protection of existing wetlands but focuses on restoring wetlands lost or altered in the past. In 1992, the appropriation provided $46.3 million for pilot programs in nine states, enrolling up to 50,000 acres. This allows Congress to see if the program is accepted by landowners under a variety of restoration opportunities in different types of wetlands. The states are North Carolina, California, Minnesota, Wisconsin, Iowa, Louisiana, Mississippi, Missouri, and New York.

The USDA Agricultural Stabilization and Conservation Service administers the program and the SCS, in consultation with the Fish and Wildlife Service, provides technical assistance for the restoration effort.

## Strict Land Requirements

Land and landowners must meet several requirements. A landowner must have owned the land for at least one year, and the land must have grown crops at least one year out of five between 1985 and 1990. The land must also have hydric soil, indicating that it once was a wetland, making the likelihood of restoring it relatively easy compared to creating a wetland. The act gives permanent easements a priority over short-term easements, but the pilot program only allows permanent or perpetual easements.

The SCS and Fish and Wildlife Service first determine land eligibility and then develop a wetland restoration plan on the eligible lands—with the landowners' involvement a key to the plan's success. A site must be restored to its original wetland condition as is "practical." But how do we do determine "practical"? Since the majority of wetlands have been altered in the past 50 years, we have numerous historical records and photos. We have employees who remember what many of these areas were like prior to being cropped. With that background, we can easily decide if the land should be a forested wetland, a prairie pothole area, or a shrub scrub wetland.

## Developing a Plan

The wetland restoration plan is developed by SCS, Fish and Wildlife Service, and the landowner. The landowner is involved in all decisions about how the wetland will be restored. The plan identifies the restoration's objective and lists all the functions and values to be obtained from the restoration. It identifies the practices required to restore the hydrology, describes the types and methods of vegetation restoration, identifies future maintenance required of the landowner, and lists all compatible uses.

The conservation easement removes all rights from the landowner except quiet enjoyment, personal hunting, and control over who can come on the property. The landowner must maintain the property and pay all taxes. In reality, all rights are removed. The plan can grant back certain compatible uses such as timber harvest, haying, grazing in controlled condition, and selling hunting rights. The plan also identifies the cost of all restoration requirements so the landowner knows the cost up front.

Landowners use the plan to submit a bid for acceptance into the program. The federal government is restricted from paying more than the appraised value of the land with the easement. Once accepted, landowners must record and file the easement with the court. SCS helps implement the restoration and monitors the easement with assistance from Fish and Wildlife.

## Choosing the Land

Establishing priorities is difficult—for example, determining which easements bidding down below the "bid cap" should be accepted into the program. Is one 500-acre easement better than a 105-acre wetland restoration? Is a wetland in Virginia better than one in California? How do you establish priorities in a national program? ASCS goes through a process called an environmental benefit index that evaluates a number of different issues. It looks at the amount of hydrology that can be restored, the location of the easement, environmental concerns such as off-site damages affecting the proposed restoration, and length of the easement. Another consideration is management risk—will someone definitely look after the restoration and make sure it will be maintained down the road?

In June 1992, one week after the program was announced, we began accepting intentions from landowners. We received 2,337 intentions on 462,000 acres from the nine states—landowners seemed to be standing at the door waiting to offer land to be restored back to wetlands. Landowners prepared restoration plans for nearly 1,400 bids representing some 250,000 acres and used those plans to submit bids by September 24 (Fig. 1).

After extensive review and considering requirements such as eligibility, bid cost, and benefits, SCS accepted 265 offerings representing over 49,000 acres of wetlands in January. We are currently finalizing plans, preparing detailed implementation plans, and waiting for landowners to file easements.

Mississippi and Louisiana landowners submitted the most eligible cropland and Minnesota, the least. Iowa landowners submitted 367 bids, the largest number; and North Carolina and New York had the fewest accepted. North Carolina bids were the largest, averaging 785 acres per easement; New York bids were the smallest, averaging 11 acres—two bids on Long Island were accepted.

In reviewing the distribution of the accepted farms by acres per farm, we find that 39 percent of the bids were from 5 to 50 acres in size. Farms over 500 acres in size represent 10 percent of the farms accepted, but represented 52 percent of the acres enrolled (Fig. 2). Landowners were willing to provide fairly large offerings.

**Figure 1.—1992 Wetland Reserve Program: intentions-bids-accepted.**

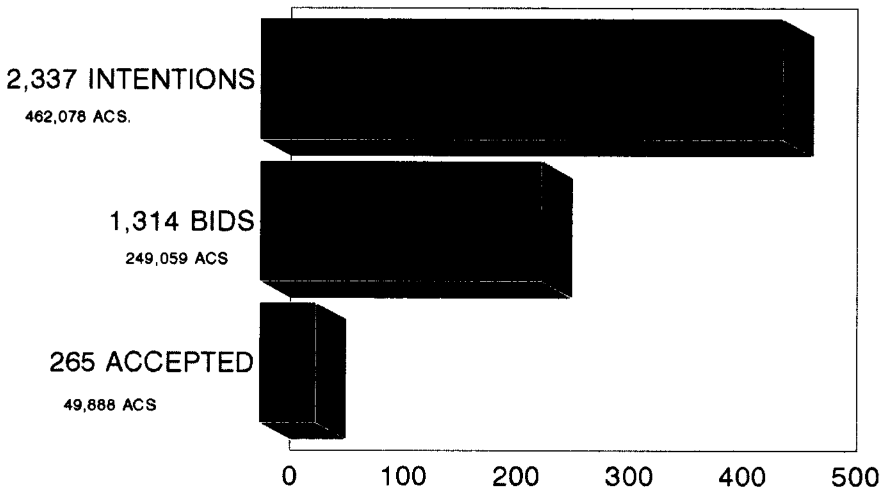



**Figure 2.—1992 Wetlands Reserve Program: distribution of accepted farms by acres per farm.**

| | NUMBER OF FARMS | PERCENTAGE OF TOTAL | ACREAGE | PERCENTAGE OF ACREAGE |
|---|---|---|---|---|
| < 5 | 9 | 3% | 39 | < 1% |
| 5 - 50 | 103 | 39% | 2332 | 5% |
| 51 - 100 | 46 | 17% | 3408 | 7% |
| 101 - 500 | 79 | 30% | 18188 | 36% |
| > 500 | 28 | 10% | 25922 | 52% |

ALL STATES

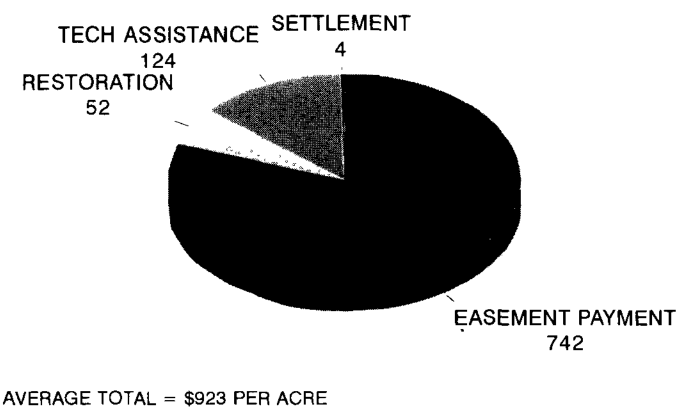
The majority of accepted acres are concentrated in a relatively small geographical area, in particular, Louisiana, Mississippi, and Missouri. Lands are more widely distributed in the midwest, more centrally located in Iowa, and concentrated in one particular area in Wisconsin. Lands in California are located in the north central.

## Variety Represented

The nine pilot states represent a variety of wetland types. In California, for example, the problems are completely different because of the water issues. In some places, like California and Mississippi, the hydrology has been so altered that it may never return to its original state. A dike with large pumps surrounds a county in Missouri to keep the water down. How could the hydrology return to its original state without shutting down the pump and flood the entire county?

The total federal cost per acre is $923. Local costs are less than $100 per acre with the easement, settlement costs, and technical assistance making up the remainder (Fig. 3).

**Figure 3.—1992 Wetland Reserve Program: per acre federal cost.**




One 100-acre easement in New York was in a muck area that had been drained with opened ditches. We put in two ditch plugs for less than $1,000 to bring back the original hydrology. So size of the easement relative to cost is important.

**Figure 4.—1992 Wetland Reserve Program: types of land accepted.**

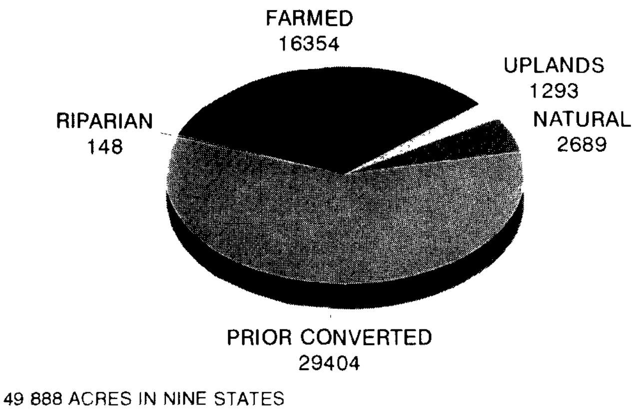
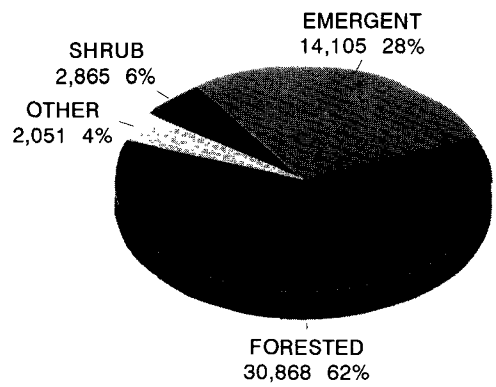



**Figure 5.—1992 Wetland Reserve Program: types of wetlands to be restored.**




USDA is targeting certain types of land: "prior converted cropland," a wetland altered substantially to easily produce an annual crop; and "farm wetlands," altered cropland with some wetland characteristics (Fig. 4). A portion of the easements sometimes contains some natural wetlands, so a small amount of natural wetlands may also be included.

The major type of wetland that will be restored is forested wetland (Fig. 5). The major type of lands, located in Mississippi and Louisiana, is bottomland hardwood; the next major type is emergent, located in the upper midwest.

## DISCUSSION

■ **Question:** You mentioned that originally the program had all permanent easements and later changed to temporary easements? What was the reason for the change and how long are the temporary easements?

■ **Answer—Don Butz:** The Conservation Reserve Program was an annual 10-year program; at the end of 10 years, it was terminated. Minor easements were only on certain practices; few acres really came in under the easement program.

■ **Question—Bill Painter:** I am a little confused—you say you have restored all of the wetlands, yet the majority are bottomland hardwoods. If those were to be cut over or the hydrology changed, you would not have anything resembling a functional wetlands for quite sometime. Why did you put such a heavy emphasis on a wetland type that takes a long time to restore, compared to some emergent types that come back more quickly?

I would like hear a history of the funding of the program since 1992. It appears to have been up and down. Also, will you receive any money if the president's incentive package goes through? And finally, do you have any data on jobs created from these programs? One way to get money for things like this is to create jobs quickly and get a lot of bang for the buck.

■ **Answer—Don Butz:** I'm not sure we really concentrated on the bottomland hardwood, although it came out that way. One reason is because more landowners bid below the appraised value. The real question is this: do you start where you can get the ultimate wetland back quickly or do you just start restoring wetlands? I'm not sure of the answer. You must start with bottomland hardwoods sometime and restore the hydrology above and beyond just planting trees.

The 1993 Congress did not fund the program, mainly to see how the pilot program went and how well it was accepted by the landowners. We have a report in to Congress, which is very responsive. I believe you will see substantial dollars in 1994 set aside for the Wetland Reserve Program to restore 350,000 to 400,000 acres.

We have no information on jobs at this point because we have not started to implement the program and put it on the land. But the costs indicate that jobs are being created.

■ **Question:** What are the future possibilities of extending the program to other states?

■ **Answer—Don Butz:** If we get substantial dollars and the acres we need, the program will go national in 1994.

■ **Question:** Will the compensation that the owner gets more than cover the taxes for 10 years? What is the incentive for a landowner to give this easement?

■ **Answer—Don Butz:** One incentive is that in the total bid process owners get compensated for the easements' appraised value. They get compensated for projected costs of maintenance—long-term maintenance cost—and soil productivity on a fluctuating scale.

The Extension Service should advise landowners accepted into the program to put aside a portion of their lump sum easement payment to pay taxes and maintain it over an extended time period.

■ **Comment:** In Minnesota, for the last three years we have taken only perpetual easements. But in the program's seven-year history, we have nearly 1,700 easements covering about 45,000 acres, the majority of which are perpetual. No one has protested continuing property tax payments.

One individual started to create a problem. In Minnesota, property taxes must be unpaid for seven years before the property reverts back to the county for disposal. This landowner was in year five and finally decided that protesting to the county was not worth it. His problem was with the county, not the state.

In the early years of Minnesota's program, counties were not required and therefore did not reduce the tax rate, even though the land was producing no economic return. However, over the years a number of counties have realized, out of a sense a guilt if nothing else, that they should lower taxes. Most of the counties are now assessing a more appropriate rate. But the obligation is on the current landowner and all future landowners to pay taxes at the current rate.

■ **Comment:** Taxes vary from state to state. In Wisconsin, for example, wetland is considered recreational land, increasing the value of the land from cropland. So landowners pay higher taxes when they restore wetlands.

■ **Question—Charlotte Wolf:** Is it feasible to apply a landscape approach to restore these wetlands and work with other agencies or groups?

■ **Answer—Don Butz:** It is feasible but not easy to accomplish. Few people really understand the landscape concept of restoration. That will be slow in coming, but we are making progress. This program allows states to establish certain eligibility criteria, and states can move in that direction.

■ **Comment:** Don and I come from agencies that traditionally are in soil and water conservation work. However, neither of us would say we are truly restorationist, ecologist, or soil and water conservation experts. Don and I need to be held accountable for things that should be on the landscape. Otherwise, our limited perspective will guide these easement areas and the millions of acres under contracts and easements. So the restoration experts need to keep us accountable for the broader public benefits that should be derived from these acres. ❑

# *PANEL: Emerging Issues in Restoration*

PANEL: *Emerging Issues in Restoration*

# *Ecosystem Management*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Eunice A. Padley
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The Forest Service has adopted a policy called ecosystem management. As an ecologist, I think the initiative holds a lot of promise for improving resource management while resolving many resource issues and conflicts. Some of its strategies involve partnerships, adaptive management, and working with other individuals and research organizations.

The Forest Service's definition of ecosystem management is a skillful, integrated use of ecological information to meet multiple-use objectives while also sustaining ecosystem diversity and productivity. A bit of controversy exists within the Forest Service and the scientific community in general about what this actually means, however. The basic questions are these: What is an ecosystem and what is ecosystem management?

Obviously, in order to manage something, you need to know what you are managing, where it is, and possess an understanding of how that something functions. Some land managers are looking at maintaining ecological processes without obtaining information on the what and where of ecosystems. The rationale is that ecosystems are too complex to define or delineate and that ecosystems have no real or only diffuse boundaries. But I disagree—although ecosystems are complex, and although we cannot rely solely on available information and reductionistic science to comprehensively understand them, we still need to tackle the problem. If we avoid it because of its complexity, we will not make much needed progress. And emerging environmental concerns and changing public expectations simply will not allow such complacency.

To discuss ecosystem management, we need to reach a common definition of each term. In a recent public meeting I attended in Duluth, forest industry representatives were upset about the new ecosystem management policy; they felt that the term "ecosystem" caused a lot of confusion. These individuals were viewing the term "ecology" as being synonymous with "preservation." While preservation is a very important aspect of ecosystem management, ecology is a science and not a political movement. Although I personally approve of the environmental movement, the movement is political and not necessarily scientific in all respects. This presentation describes what an ecosystem is and is not.

## Management Defined

I recently was privileged to speak at a President's Council of Environmental Quality—EPA joint session in Boston. I followed a Harvard professor whose topic was tools for managing biological diversity. But he talked about our inability to manage biological diversity because of the complexity of ecosystems. He discussed theories of chaos, and he was absolutely brilliant. I had a problem, however, since my topic was ecosystem management. So I ran down to the front desk, got a dictionary out, and looked up the word "management." I found that management means to render submissive, to dominate, to achieve objectives, to use sparingly, to tender, or to husband—in other words, it means everything from Mother Theresa to Adolph Hitler.

To the Forest Service, management means to carefully achieve objectives using judgment and scientific methods. The objectives of ecosystem management are to meet people's needs while ensuring that national forests and grasslands represent diverse, productive, and sustainable ecosystems. Decisions ranging from the extraction of commodities to the preservation of wilderness are all management decisions. A difference exists between human dominated landscapes, which really happen arbitrarily, and human managed landscapes. The latter represent careful analysis, management, and monitoring for achieving multiple-use management objectives.

When I spoke in Boston following that really wonderful thinker, I pointed out that if we cannot even identify what an ecosystem is, we are in real trouble, since it is obvious that we can affect them. To demonstrate, I pulled out my Michigan fishing license that said that children, pregnant women, and women planning on having children should not eat fish harvested out of this Great Lake ecosystem.

Ecosystem management is a means or tool to meet multiple use and sustained yield mandates while attending to other critical needs, including the conservation of biological diversity. The President's Council on Environmental Quality has issued new guidance on implementing the National Environmental Policy Act for conserving biological diversity. The report makes several recommendations: (1) that we must assess biological impact using landscape analysis, and agencies must look beyond site level effects to assess impacts within local ecosystem, landscapes, or broader regional contexts; (2) that we need to minimize fragmentation and promote conductivity of natural areas; (3) that we need to mimic natural processes; and (4) that we must look beyond species and protect the ecosystem. This does not mean we should ignore species or supplant those efforts with ecosystem and landscape-level efforts. Instead, we must augment species-level efforts and try to arrest the decline in biological diversity before a species becomes threatened or endangered.

## Ecosystem Defined

In 1935, Tansley introduced the term "ecosystem," and the explicit idea of ecological systems defined by abiotic and biotic factors of climate, physiography, soil, water, plants, and animals was formally expressed in our language (Major, 1969; Cleland et al. 1992). The ecosystem concept brings the biological and physical worlds together into a holistic framework within which ecological systems can be described, evaluated, and managed (Rowe, 1991).

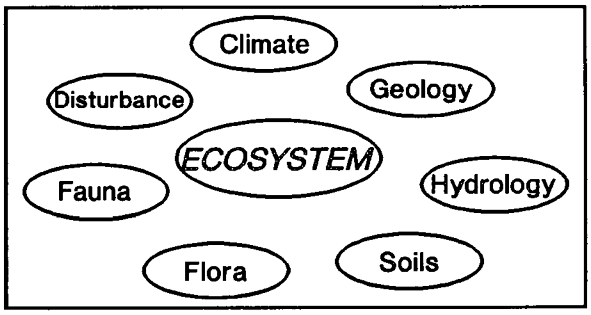
Ecosystems are volumetric segments of landscapes and waterscapes composed of associations of factors that vary at different spatial scales (Rowe, 1980). Ecosystems are defined by the interactions of their biotic and abiotic components that occur within and across different hierarchical levels. Ecosystems change through space and time. Ecosystems are not simply species, biotic communities, or underlying environments. Nor are they simply geographic areas such as administrative units (e.g., counties or national forests) or watersheds. By recognizing these fundamental properties, we can begin to understand how conditions and processes affect their stability and resiliency.

Ecosystems are scale-dependent phenomena whose boundaries depend on specific parameters of concern or interest. The globe is an ecosystem. Lake Superior is an ecosystem. A 10-acre, 40-acre, or 100-acre piece of forest land that folks are comfortable seeing, touching, and comprehending is an ecosystem. A few grams of soil are ecosystems. All of these earth segments are composed of living and non-living elements. They undergo interactions and processes like succession, natality, and mortality.

## Multiple Factors and Ecosystems

The occurrence, distribution, and vigor of biota are largely regulated along energy, moisture, nutrient, and disturbance gradients. These gradients, in turn, are affected by climate, physiography, soils, hydrology, flora, and fauna (Hix, 1988; Cleland et al. 1985; Spies and Barnes, 1985; Barnes at al. 1982; Jordan, 1982). Integrating these ecological factors at their respective scales of influence define and delineate ecosystems (Fig. 1).

**Figure 1.—Multiple factors comprise ecosystems.**




While the association of multiple factors is all important in understanding ecosystems, all factors are not equally important in defining ecosystems at all spatial scales. The important factors at coarse scales are largely abiotic or physical variables (e.g., macro-climate, gross physiography), while both biotic and abiotic factors are important at finer scales (e.g., micro-climate, soils, vegetation).

Macro-climate dominates ecosystems at all spatial scales. Photoperiod, temperature, and precipitation exert primary control over the structure, composition, and genetic differentiation of plant populations (Denton and Barnes, 1988). At macro-scales, ecosystem patterns correspond with climatic regions, which change mainly due to latitudinal, orographic, and maritime influences (Bailey, 1987; Spurr and Barnes, 1980).

Within climatic regions, physiography or landforms modify the intensity and flux of solar energy and moisture. Varying elevations, slopes, aspects, and geologic parent materials cause large variations in temperature and moisture within climatic regions (Bailey, 1988; Rowe, 1980). Landforms affect organism movement, watershed orientation, and the frequency and spatial pattern of disturbances such as wind and fire (Swanson et al. 1988). Soils develop in parent materials on the mantle of landforms; hence landforms often exhibit patterns in soil characteristics, as well as patterns in vegetation (Host et al. 1987; Forman and Godron, 1986; Rowe, 1984).

Within physiographic regions, vegetation changes with local topography and soils. Topography causes variations in micro-climate and water drainage patterns (Bailey, 1987; Omernik, 1987). Within plant rooting zones, soil physics, chemistry, and microbial populations govern moisture and nutrient availability. Thus, soils exert a strong influence on vegetation and indirectly affect wildlife populations.

Flora and fauna are integral components of ecosystems (McNaughton, 1983; Pregitzer and Barnes, 1984). Flora mediate in situ levels of light, temperature, and moisture, and affect soil development processes, nutrient cycling, and carbon storage (Waring and Schlesinger, 1985). Fauna rely on vegetation for food and shelter and affect ecosystem developmental through seed predation or dispersal, selective herbivory, and many other mechanisms (Marquis and Brenneman, 1981; Gysel and Stearns, 1968). Micro-flora and micro-fauna are critical biogeochemical processors that all life forms depend upon; they produce oxygen, fix nitrogen, and reduce carbon from organic to inorganic forms.

Disturbance regimes affect species distributions, community structure, and landscape patterns. Wildfires, blowdowns, insects and disease, and other forms of disturbance modify ecosystems at a variety of spatial and temporal scales (Heinselman, 1973; Shugart and West, 1981; Runkle, 1982; Grimm, 1984; Knight, 1987). Human activities have long influenced ecosystems throughout the world, but increased human population pressures and advanced technologies are accelerating the rate and magnitude of human induced change as never before. Humans as integral components of ecosystems, which both affect humans and are affected by them, are central to the ecosystem management concept.

## Spatial Scales and Nested Hierarchies

Ecosystems exist at many spatial scales, from the global ecosystem down to regions of microbial activity (Meetenmeyer and Box, 1987). Ecosystems can be conceptualized as occuring in a nested geographic arrangement, with numerous smaller ecosystems within larger ones (Allen and Starr, 1982; O'Neill et al. 1986; Albert et al. 1986). This hierarchy is organized in decreasing orders of scale by the dominant factors controlling biological and ecological systems. Conditions and processes within larger ecosystems superpose those of smaller, embedded ecosystems; properties of smaller ecosystems emerge within larger systems (Bailey, 1985).

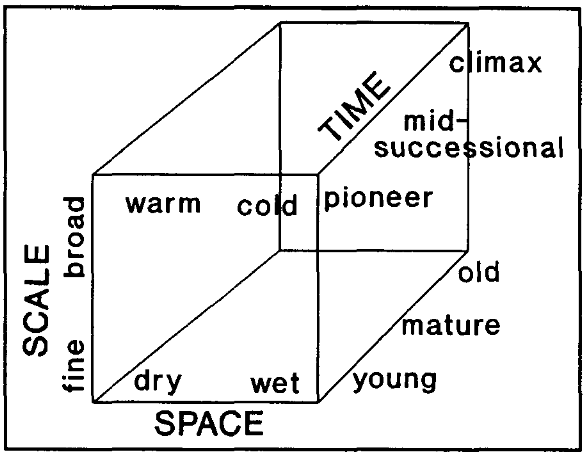
Discerning management's effects on ecosystems requires examining conditions and processes above and below the level under consideration (Rowe, 1980). For example, timber harvesting affects not only the stand level but also the micro-site and landscape levels; these effects may be harmful or beneficial (Noss, 1983; Andren and Angelstam, 1988). A major ecosystem management challenge is to distinguish natural associations of ecological factors at different spatial scales and to understand natural and human-induced processes within and across these different organizational levels.

## Spatial and Temporal Variability

Since the structure and function of ecosystems change through space and time, we must consider both spatial and temporal variability while evaluating, mapping, or managing ecosystems (Delcourt et al. 1983; Forman and Godron, 1986). The many states of life and environment that we observe through space are spatial sources of variability; the changes in these states through time are temporal sources of variability. Figure 2 shows spatial variations measured at local and regional scales, and temporal variations measured in years and centuries.

The effects of spatial and temporal variability on animal species are illustrated by the local and landscape ecosystems of the Kirtland's war-

**Figure 2.—Spatial and temporal sources of ecosystem variability.**




bler (*Dendroica kirtlandii*), the Karner blue butterfly (*Lycaeides melissa samuelis*), and the black bear (*Ursus americanus*).

The Kirtland's warbler, a federally listed endangered species, is endemic to jack pine ecosystems in the northeastern part of lower northern Michigan. This area has a relatively cold macroclimate (short growing seasons, low winter temperatures), and is composed primarily of glacial outwash plains with xeric sandy soils. This climate constrains succession in outwash sands to conifer-dominated communities. Variations in regional climate, landscape level landforms, and local level soil conditions, then, determine the warbler's spatial niche.

The Kirtland's warbler inhabits jack pine stands generally between 6 and 23 years old and 5 to 16 feet high (Probst, 1991). As these stands grow older or change temporally, they become unsuitable habitat for this endangered species and favor other species under changed conditions. Thus, both spatial and temporal sources of ecosystem variability affect this species' habitat distribution, and consequently its population viability. The Kirtland's warbler has a very narrow spatial and temporal niche, or a narrow ecological amplitude in space and time.

The Karner blue butterfly, also a federally listed endangered species, inhabits oak savannas in outwash plains in southwestern lower Michigan. This area has a relatively warm macro-climate, compared to northeast Michigan. This warm macro-climate allows succession on xeric outwash sands to proceed to pin and black oak communities, as opposed to the conifer dominated communities common in northeastern lower Michigan. The Karner blue's spatial niche, differs from that of the Kirtland's warbler because of regional climate, although both species occupy very similar landform and soil areas.

Oak savannas in Michigan are perpetuated by more frequent fire disturbances than the jack pine ecosystem of the Kirtland's warbler. Oaks are coppicing species, which do not depend on progeny of seed origin to restock an area following fire. Restocking surveys conducted by the Huron-Manistee National Forests for several years following the Mack Lake fire, show that jack pine needs from one to several decades to mature and produce enough viable seed to re-establish the next generation in stem densities required by the Kirtland's warbler. In a sense, the Karner blue uses a different spatial and temporal niche than the Kirtland's warbler.

The Kirtland's warbler and Karner blue butterfly are both fire-dependent species that occupy xeric soils in Michigan outwash landforms. These species' habitats differ, however, because of spatial and temporal variability sources. The Kirtland's warbler and Karner blue butterfly's narrow niches must be available in both space and time if the dependent species are to survive. In today's society, these niches will be actively restored or maintained through ecosystem management. If left to chance, unmanaged rural development, fire suppression, and other human activities will cause further decline of species populations.

A third example, the black bear—a state-listed sensitive species in Michigan—uses xeric jack pine communities to forage on blueberry and bearberry; dry-mesic pine-oak communities to forage on hawthorn and maple leaf viburnum; mesic northern hardwood communities to forage on ribes, jack-in-the-pulpit, and wild leeks; and wetlands to forage on several species and to escape from human predation (Rogers and Allen, 1987). In regenerating forests, the black bear forages on light-loving plants including blackberry and raspberry; in mature forests, it forages on the aforementioned species; and in over-mature and old growth forests, it forages on insects inhabiting dead and dying trees.

The black bear inhabits many spatial and temporal niches throughout its range and has an extremely wide ecological amplitude, compared to the Kirtland's warbler or Karner blue butterfly. Resource managers can enhance bear population viability, however, by evaluating requirements based on spatial and temporal sources of ecosystem variability at multiple scales. Spatial states, or conditions of life and environment, affect ecological processes; understanding the interactions forming processes helps to define class limits of ecologically variable associations. Thus, spatial and temporal variations should be examined together to manage species and the dependent ecosystems.

## Effects of Scale on Attributes of Change

The attributes of change through space and time vary according to scale of observation. To understand ecosystems, we must understand how differences in spatial and temporal scales affect our perceptions of the world around us.

Space and time are generally related. Changes over large spatial areas generally require long time periods; changes over small areas often occur within short periods (Fig. 3). Although change is intrinsic to ecosystems, the rates of change of interest to ecosystem managers are not so great as to make them incomprehensible or unquantifiable. Indeed, human concerns about changes, particularly changes we are responsible for or affected by, led to the evolution of management into an ecological approach. Concepts of change like homeostasis, stability, and resiliency are more meaningful from the perspective of natural associations of space and time.

**Figure 3.—Change at commensurate spatial and temporal scales.**

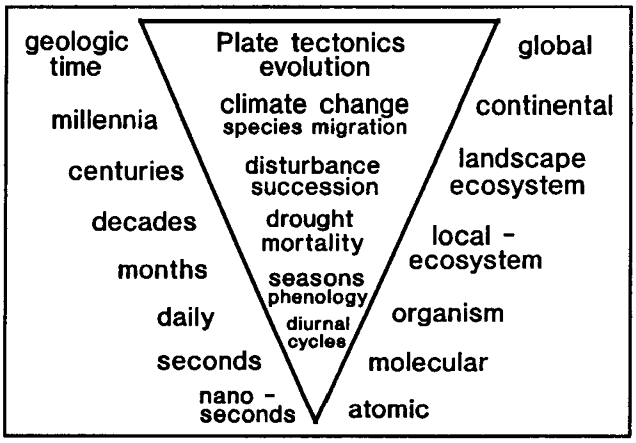



Figure 3 shows examples of environmental and biological changes that have occurred at commensurate spatial and temporal scales (Forman and Godron, 1986). Plate tectonics has altered evolution at a global scale over millions of years. Climate change has altered species distributions at a continental scale over thousands of years. Episodic disturbance through fire has altered landscapes over centuries. Meteorologic drought has altered growth and mortality of organisms and local ecosystems over decades. Seasons have altered the phenology and physiology of plants and animals over months. Diurnal cycles have altered individual organism's habits daily (e.g., photosynthesis, sleep cycles). Within organisms, molecular reactions such as metabolism have occurred within seconds. Within molecules, atomic reactions have occurred within nano-seconds.

This natural space-time association has numerous implications. The first is that ecosystem managers should consider rates of change according to a particular phenomenon and its relative spatial and temporal heterogeneity. A second implication is the prospect of evaluating human effects on complex ecological systems from our knowledge of natural space-time associations. At a global scale, for example, some are concerned that climate is warming at an unprecedented rate from a greenhouse effect. This is an example of a human-induced alteration of a natural time-space relationship. If climate changes within periods several orders of magnitude less than natural rates, species and ecological systems' ability to adapt and compensate through migration or other mechanisms at commensurate spatial scales may be exceeded.

## Ecosystem Management

Ecosystems are defined by organism interactions and the environments in which they occur. Granted, relating life forms to environment is complex. Understanding the physiology and life histories of individual species, the biogeography of species and communities, and the processes taking place within and across ecosystems encompasses many scientific disciplines. Making progress in ecosystem management will therefore require a long- term commitment to integrated research and management.

From a practical viewpoint, ecosystem management involves placing traditionally managed elements, such as commercial tree species or popular game species, into a broader context of the intrinsic and spiritual values of all ecosystems (e.g., their history, complexity, beauty, and cultural significance). This more comprehensive approach does not mean that using natural resources to meet human needs is being diminished. On the contrary, understanding and protecting ecosystem processes is essential to ensure a lasting supply of the materials and commodities that people require.

To manage ecosystems, we must advance our ability to predict how processes will change present conditions; these changes will occur within a range of possibilities set by ecological potentials. Management for an endangered species that is obligate upon a specific habitat, for example, depends on an area's potential to support that habitat and the endangered species. Successful management for any species or ecosystem depends on our knowledge of existing conditions; biotic, physical and ecologic processes; and underlying potentials regulated along environmental gradients.

Species and ecosystems are being affected, deliberately or inadvertently, by the introduction or exclusion of different types of disturbance (Swanson et al. 1990). Excluding fire in jack pine and oak savanna ecosystems is a form of disturbance that has adversely affected these ecosystems and their dependent populations, including the Kirtland's warbler and Karner blue butterfly. Harvesting timber, prescribed burning, and planting of jack pine seedlings are also disturbances that have advantageously affected the Kirtland's warbler populations.

In managing forested ecosystems, we may be able mimic natural disturbance regimes using various silvicultural systems. Noting the nature, spatial and temporal scale and pattern of disturbance with which ecosystems codeveloped will provide management models that can be tested, verified, adjusted, or refuted as appropriate. This will require long-term research.

## Conclusion

Managing ecosystems has practical implications for the sustainability of humankind as well as other species. In 1966, the prominent scientist Eugene P. Odum presented a presidential address at the Ecological Society of America (Odum, 1969) stating

> *Man has been generally preoccupied with obtaining as much "production" from the landscape as possible. . . . But, of course, man does not live by food and fiber alone; he also needs a balanced $CO_2$-$O_2$ atmosphere, the climatic buffer provided by vegetation, and clean (that is, unproductive) water for cultural and industrial uses. Many essential life-cycle resources, not to mention recreational and aesthetic needs, are best provided man by the less "productive" landscapes. . . .*
>
> *Until recently mankind has more or less taken for granted the gas-exchange, water purification, nutrient-cycling, and other protective functions of self-maintaining ecosystems, chiefly because neither his numbers or his environmental manipulations have been great enough to affect regional and global balances. Now, of course, it is painfully evident that such balances are being affected, often detrimentally. The "one problem, one solution approach" is no longer adequate and must be replaced by some form of ecosystem analysis that considers man as part of, not apart from the environment.*

As a management recommendation, Odum proposed that

> *We can compromise so as to provide moderate quality and moderate quantity on all the landscape, or we can deliberately plan to compartmentalize the landscape so as to simultaneously maintain highly productive and predominantly protective types as separate units subject to different strategies (strategies ranging, for example, from intensive cropping on the one hand to wilderness management on the other). If ecosystem development theory is valid and applicable to planning, then the so-called multiple-use strategy, about which we hear so much, will work only through one or both of these approaches, because in most cases, the projected multiple uses conflict with one another.*

These statements are more relevant today than they were 27 years ago. Public opinion and expectations have caught up with this thinking, and the policy of ecosystem management was born as a consequence.

Although ecosystems are extremely complex, we can formulate meaningful hypotheses, conduct research, and improve management by taking an ecological approach. It is time to marry ecological concepts with natural resource management and research to ensure that natural systems and the well-being of species dependent upon them, including humankind, are sustained.

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PANEL: *Emerging Issues in Restoration*

# *Landscape Ecology as a Restoration Tool*

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A key question to be addressed in this symposium is how to apply concepts of biodiversity, conservation biology, and landscape ecology to restoration. These three concepts are strongly linked, as I will briefly review here.

## Defining Landscape Ecology

Before relating landscape ecology to restoration, we need to define landscape and landscape ecology. A common definition of a landscape is an area on the earth's surface that contains several kinds of ecosystems. A landscape might contain different kinds of forest systems—for example, in parts of the upper Midwest, a natural landscape might consist of closed forest, savanna, and prairie. These systems are closely linked through the ecological processes that transcend their boundaries. Aquatic systems may also be interspersed throughout the landscape. Typically, landscapes can include disturbed or undisturbed natural elements as well as dominating human elements such as agriculture, roads, and settlements.

The spatial arrangement of these different landscape elements (both natural and human-dominated), as well as their size and shape, is referred to as landscape pattern.

Another important component of landscape is spatial scale. This is typically several square kilometers, which reflects our anthropocentric view of the world, although some landscape ecologists look at one- or two-square-meter landscapes relating to beetle movement and other similar measurements. Finally, because all systems are dynamic, landscape ecology includes a temporal component.

Landscape ecology is the study of different ecosystems, the processes that link them, and the effects of disrupting one or more ecosystems. What processes are then compromised, and how can we mitigate these effects? For example, what might happen to a natural forested landscape subjected to human disturbances? An essentially pristine forested landscape in the upper Midwest may have a variety of forested ecosystems dominated by birch and sugar maple, various kinds of pines, a mixture of hardwood species, areas disturbed by wind, and several kinds of aquatic systems. Within each of these ecosystems are particular complements of vegetation and wildlife and a suite of ecological processes such as dispersal, nutrient flows, and water flows. Thus, landscapes are just one important component of an ecological hierarchy, which ranges from organisms to landscapes.

## Ecosystem Components

The ecosystem is one component of a land area that includes biota, soil, wind, and temperature. The species populations—the biotic component—along with the abiotic component give us the ecosystem. Communities are groups of species populations that occur at the same time in the same place. If you disrupt a population, remove it all together, kill off a sizeable portion of it, or present some barrier to the individuals' interactions within that population, the entire community is affected. If an entire species is removed, then the remaining species will interact differently. Any change to the community changes the ecosystem and creates implications at the landscape scale. So, links occur not only between populations and communities, but also between communities and landscapes.

Some of these interactions may be obvious—others may be subtle. The landscape, or restoration, ecologist's challenge is to discover how to reconstruct these broken links.

## Shifting to Broader Considerations

When appropriate, our focus as traditional ecologists, restoration ecologists, or land managers must shift from specific impact studies to broader considerations. This idea is not new. The National Environmental Policy Act advises us to consider an activity's entire suite of environmental consequences. And the President's Council on Environmental Quality has long been advocating a broader scale approach to environmental impact assessment.

Landscapes are a very important consideration, but they are only one component of the ecological hierarchy. To restore land areas, we must understand interactions and how ecosystems are linked. Disturbance is a compounding factor and an important phenomenon in ecology. Some ecosystem types are more susceptible to disturbances than others. For example, oak savannas are more susceptible to fire than mesic beech-maple forests. A recently disturbed landscape will have a new patchiness or pattern. Understanding the natural recovery process is important for successful restoration.

The Flambeau River area in northern Wisconsin experienced a severe wind storm in 1977. The old-growth white pine northern hardwood forest was essentially decimated. Large areas were completely destroyed, although some potential seed source areas were relatively undisturbed. The patterning after the storm was very different than it was before the storm. Changes occurred rapidly in the initial succession process.

Within three or four years, the dominant vegetation was essentially a raspberry thicket. The bear population exploded. Different wildlife species took advantage of different forest materials.While the aquatic systems are relatively undisturbed, as nutrients and sediments wash down from these exposed soils into the aquatic systems, over time they too will undergo some changes—but on a different temporal scale. Therefore, the hydrologic processes are also important.

Other ecological systems areas are prone to fire. Following a fire, relatively undisturbed areas might be interspersed with burned areas, altering the processes and the links. Any disturbance may occur at one temporal scale, while the recovery process occurs at a different order of magnitude.

One of the most dramatic kinds of human disturbance is in the upper Midwest where large areas of forest have been cleared and converted to agriculture. This kind of disturbance to natural systems is a principal focus of landscape ecology and restoration. Following deforestation and conversion to agriculture, an agricultural landscape might contain remnants of natural old growth forests. The landscape in Green County, Wisconsin, on the Wisconsin/Illinois border, has some areas of relatively undisturbed old growth forest, areas of second growth forest within the intervening agricultural landscape, some riparian forests along streams, and small areas of scattered trees along some intermittent streams.

## Creating New Landscapes

As a consequence, we have created a new landscape. Because of the altered ecological and environmental conditions, the species typical to the landscape before human intervention must cope with a new kind of environment. If they are unable to cope, they may be prone to local, regional, or even global extinction. To restore communities or ecosystems in this landscape, we need to understand which environmental conditions have been altered by human impact and which need to be restored to bring back certain species or groups of species.

These altered landscape environmental conditions result from fragmentation and depend in some part on patch size. Remnant patches in most highly disturbed human-modified landscapes have a wide size distribution. The Siuslaw National Forest in the Pacific Northwest has a large number of small remnant patches and a small number of large patches—typical also of the agricultural landscape in southern Wisconsin.

These remnant patches of forest within a landscape alter the microclimate around the forest edge. This is sometimes referred to as the "edge effect"—the edge of the forest tends to be brighter during the day than the interior. In addition, the edge may be windier and drier. Greater temperature extremes and an altered microclimate around the forest edge allows encroachment of species that might be undesirable or thwart some of the native species. If the patches are above a certain critical size, the forest interior conditions might still be able to support typical regional species. As the patch size is reduced, the edge width will remain about the same, but the interior area will decrease markedly. As the patch gets smaller and smaller, eventually the entire patch contains edge microclimate conditions. Therefore, even with green landscape patches, conditions are conducive to harbor primarily weedy, exotic, or undesirable species. In restoring a landscape, we must be aware of this phenomenon and manage for patches above a critical size to avoid purely edge patches.

## Fragmentation Issues

Species dispersal problems are another implication of fragmentation. With patches scattered throughout a landscape, how do species get from one area to another? Large birds move about fragmented landscapes quite readily, but small mammals may have difficulty traversing the hostile environment of an agricultural field. Therefore, patch size and location have important effects on species dispersal in landscape ecology.

My colleague, Carter Johnson at Virginia Polytechnic Institute, studied seed dispersal from isolated basswood, sugar maple, and ash trees in old fields by measuring the distance of the seedlings to determine their effective dispersal distance. He found that basswood seed dispersal may be 40 meters from its seed source; sugar maple may be 90 to 100 meters; and ash may be 300 meters. What happens if landscape patches are greater than those distances?

In comparing today's southern Wisconsin landscape pattern to the pattern in 1882, we find that 100 years later a large portion of forested area has been cleared for agriculture. Forest patches are much smaller and considerably farther apart—from an average distance of 150 meters in 1882 to over 400 meters today. Even though stands are isolated physically, they may be connected by the seeds' dispersal distances if those dispersal distances are sufficiently great. Fragmentation is not necessarily a problem if dispersal is maintained. However, in many instance patches do remain isolated. Activities such as overgrazing and logging have exacerbated the problem of restoring lost species, short of actually growing seedlings and planting them.

## Using Existing Policies

One way to "reconnect" landscapes is to take advantage of policies already in place. Justifying the continuation and expansion of agricultural policies such as the Conservation Reserve Program is important for reasons beyond soil erosion control. If all eligible agricultural lands were enrolled in the Conservation Reserve Program, the landscape pattern in the southern Wisconsin area would revert to a condition similar to that in 1882. As a result, this landscape would become "linked" or reconnected as fields were set aside and allowed to go through natural succession.

Another way to restore the landscape is to establish vegetative corridors and make sure they are not destroyed. For example, a 16-hectare area of old growth forest containing species typical of the region is connected to a small highly grazed area that also contains a large proportion of such species, thanks to the existence of corridors.

These corridors allow the dispersal of certain species that may not be capable of crossing a much larger distance. The corridors do not necessarily need to be intact, but they do need to be connected enough to allow species to migrate through the landscape. Recent ecological literature is controversial regarding the relevance of corridors. However, I see no harm in establishing and maintaining corridors. If one cannot reconstruct a presettlement landscape, at least one can consider patch size and isolation, using corridors to reestablish some of those links.

## Disconnected Patches

A Canadian landscape ecologist directed a study comparing field mice population sizes in connected patches with those that were isolated. Simulation models showed that in isolated areas, the population sizes of mice were much lower than in connected patches. The importance of this is that a high population size of mice maintains a high population of predators, with a cascading effect throughout the landscape.

Other restoration ecologists have looked at the importance of fragmentation. Jerry Franklin and Richard Forman studied an area in the Pacific Northwest and showed that as the landscape became more and more fragmented, the incidence of fungal and insect pests increased. In addition, as smaller patches become a larger component of the landscape, the probability of ignition and burning increases because of the increased amount of windier and drier edges surrounding isolated patches.

Another consideration is that if, under the Conservation Reserve Program, a modest amount of land were to be enrolled in perpetuity, the total forest area would increase considerably, increasing the amount of interior forest relative to forest edge. The decreased distance would bring some patches within dispersal distance of many species, which would effectively reconnect the landscape.

## The Biodiversity Issue

An important but overlooked result of patch isolation is the effect on biodiversity. Biodiversity includes not just the number of species inhabiting an area but also their genetic diversity. Isolated patches affect species physical movement across the landscape and can impede the flow of pollen (i.e., genetic material). Patches may become isolated, and the genetic diversity that characterizes those populations within the larger region could be reduced. While we do not know the full implications, we suspect that reducing genetic diversity prevents species from adjusting to changing conditions caused by human activity or to long-term natural processes. In small mammals that cannot cover great distances, for example, some loss of genetic diversity may occur. For long-lived tree species, some rare alleles are not present in smaller, overmanaged, or overgrazed patches in the Wisconsin landscape. If that process were to continue, a great deal of genetic diversity could be lost from the landscape.

The landscape ecologist, the conservation biologist, and the restoration manager must consider these myriad effects and their implications. This is a daunting task. The challenge is to promote ecologically sound restoration by integrating a broader landscape approach, while being cognizant of population dynamics and considering temporal and spatial scales necessary to protect and enhance biotic diversity. ❑

## PANEL: Emerging Issues in Restoration

# General Panel Discussion

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*Argonne, Illinois*

**Question:** Dave Cleland commented on the private lands located within old growth areas and questioned the success of getting landowners involved. Do you see the Forest Stewardship Program as being a potential opportunity to get private landowners involved in this kind of a program?

■ **Answer—Dave Cleland:** I would like to see that. The political reality is that private landowners oftentimes view Forest Service activities as posing a threat, and they do not want Big Brother telling them how to manage their lands. State and private forestry was intentionally excluded from the ecosystem management policy because of the possible political backlash. In the eastern United States, on the other hand, because of the dispersed ownership patterns, the National Environmental Policy Act requires federal agencies to consider all proposed actions, federal or not.

Therefore, we must factor how private landowners and state agencies actions will affect our management strategies. But we cannot dictate their actions.

This is a complicated problem. In a meeting last week, someone in industry pointed out that many private land owners are tree huggers, whose lands are contributing to an interior habitat, for which we are not accounting in our management practices.

■ **Question:** Chris Dunn referred to genetic diversity loss in isolated populations. We have been working with salmon, which tend to isolate and return—not as much as literature would have you believe—to their birthplace in periodic intervals to rebreed. This is not a reduction in genetic diversity in the metapopulation, although each subpopulation becomes isolated as they adapt to the selective pressures in their particular environment. This results in one large adapted metapopulation and many small specially adapted and probably not very plastic subpopulations.

By overlaying this onto the landscape, units start connecting to get those populations back into breeding, depending on the behavior of the species. As plant communities become more isolated, each subcommunity becomes genetically less diverse and the metapopulation has a larger array of genetic types.

■ **Answer—Christopher Dunn:** Addressing long-lived species such as trees is difficult. However, some work has been done with sugar maple seedlings, saplings, and mature trees. Populations defined by mature trees maintain genetic diversity. But genetic diversity is much less in seedling populations.

Although the process is more difficult, further study may determine if the genetic diversity loss in seedlings is due to fragmentation. Many expect that it might be. Another issue is whether the loss of genetic diversity would be restored after going through a genetic bottleneck.

■ **Comment—Dave Cleland:** One theory about high diversity within tropical rain forest relates to changing climate. It involves the warming and drying period resulting in isolated populations, followed by a cooling trend, resulting in tremendous genetic diversity. But if these populations are isolated and losing diversity and plasticity, the potential for adverse impacts is large.

■ **Comment:** Over the last few years, I have been increasingly concerned about the use of certain terminology. Specifically, when we say we are restoring ecosystems, we might more appropriately say that our goal is to restore an ecosystem. In fact, all we are talking about is restoring habitats or a particular condition in time and space. Our goal may be bigger—to restore an entire ecosystem—but while we may have restored a wetland habitat, we have not in fact restored the system's function or total ecosystem capacity.

■ **Answer—Dave Cleland:** Terminology is a problem. To me, habitats are ecosystems in relation to the animals that use them. In restoring habitats that must support wildlife population or other populations, the ecosystems will function if the restoration is done appropriately.

But your question about recognizing restored and functioning ecosystems that support the entire compliment of species is difficult to answer. That is why consideration of temporal scale must be involved both in research and practical application.

■ **Question:** In Ontario, our systems are slightly different but the principles still apply. If, as part of a restoration plan, we are obliged to reinstate or replace something that might have been there, success must be defined on a relative scale. How long is long enough to define the success of a project? We are looking at fairly long windows for some of these systems—for example, terrestrial systems—to be put back in place. So when do you sign off on a project? In restoring a habitat, that is one consideration, and over time it may evolve into a component of the total system.

■ **Answer—Christopher Dunn:** Restoring a beech-maple forest with all the different stocks of wildlife is a huge task. You need to define the goal. Many have made a distinction between the terms restoration, rehabilitation, and reclamation, particularly Tony Bradshaw, a British ecologist. Once you determine your goal, then you know what processes and species to reintroduce. To simply control erosion into an aquatic system, where you put the soil during excavation may not matter as long as sedimentation is reduced. Putting a beech-maple forest back may not be the issue—any kind of land cover may be sufficient. The hierarchy of restoration, not ecological hierarchy, may be the issue.

■ **Comment:** Habitat is usually defined as a specific area where interacting living and nonliving biotic factors provide at least minimal life support conditions for a given species.

■ **Answer—Dave Cleland:** I do not feel badly about the term ecosystem because my orientation avoids dealing with minuscule pieces. This is similar to dropping a mirror and examining each piece to try to restore it to get an accurate reflection. This prevents progress.

We cannot comprehensively quantify the myriad processes and structural functioning attributes of ecosystems. Human medicine cannot do that. Complexities are inherent in dealing with biological and ecological systems, but we need to get on with understanding ecological systems at various scales. Although the single species approach is necessary, it cannot be used alone.

■ **Question:** What is the width of the edge effect in a mature beech-maple forest in the Great Lakes Basin? What sort of edge effect would you find in the same forest if you now had hemlocks and white pines?

■ **Answer—Christopher Dunn:** In a beech-maple forest in southeastern Wisconsin, the edge effect is between 50 and 100 meters. Any patch less than a couple of hectares will have edge conditions throughout.

■ **Question:** Does the width change much with the percentage of coniferous trees?

■ **Answer—Christopher Dunn:** I do not know. I would suspect the edge effect might be less, but I should refer that to someone from northern latitudes.

■ **Question:** We have talked a lot about sustainable yield and ecosystem restoration but not about allowing natural evolution to reestablish itself and take it course. What is the future of the three competing management strategies—managed sustainable, versus ecosystem restoration, versus natural evolution?

■ **Answer—Dave Cleland:** Regarding the biotic edge, the environmental edge effect of 100 meters may be one measure. But deer browse, for example, and the edge can extend farther.

In approaching competing uses—restoring, managing, deriving products versus wilderness—we need to accommodate each. Man is part of the ecosystem. If we were to put everything in a preservation mode, every four or eight years we would have a new president and conditions would flip-flop back and forth. The management outcome would be long lasting while the short-term political decisions would be arbitrary. ❑

# *Recommendations for Action*

# Recommendations for Action
# Research Needs

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The following is a summary of issues requiring research support. These issues are not in priority order.

## Information Technology Compendium

We need an information technology compendium. Since both regulators and the regulated are often faced with not having the best information, useful information must be made available in a timely fashion and in an easy-to-use form. For example, if it is important to use a plant species, information on effective use should be readily available.

The compendium should contain information such as a definition of success, references to provide a means for comparison, and comments about successful reclamation projects.

## Focus on Both Elements and Systems

Restoration projects are seldom successful when the project focus is too narrow. Restoration must consider systems as well as elements. We need to know the ecology of the organisms in the systems in questions. We should know tolerance ranges, capacities, and other factors that contribute to successfully establishing and maintaining an organism. Since we cannot ignore the organism's operation in the associated environmental system, we also need to build an understanding of the nature of those environmental systems. In many respects, our research is inadequate to address many system issues.

## System Trajectory Issues—Starting and Ending

Another research area relates to system trajectory issues and the need to have some idea about starting and ending points, particularly in a regulatory context. However, we need to recognize that ecological systems are constantly changing and progressing along a successional gradient operating within some environmental constraints. Multiple stable states and alternate trajectories for development offer alternatives in restoration planning, but we need to develop a better understanding of ecological systems and how they progressively change.

We may, for example, establish and achieve a restoration goal. But within a relatively short time period because of the natural system's progression, the goal that was met is no longer being met. Goals may change. How, then, do we judge success or failure?

## Systems Integration Needed

Systems integration is the area that needs the most attention. Starting with basic information about the landscape and incorporating historical elements gives us a better context and a landscape view. With this perspective, we can then integrate the technical, social, and economic factors that relate to and affect the ecology or ecosystems.

Canadians, particularly under the Great Lakes Water Agreement, have identified an ecosystem approach that deals with integrating environment, economy, and society. The Europeans are also a bit ahead of us on this integration. Significant research could involve all parties, incorporating the information presented in the past few days, to improve our integration capacity.

## Continuing Learning

This may not be a clear-cut research issue, but continued learning and effective communication are essential parts of research. For example, people in our agencies are overworked simply by doing day-to-day tasks, leaving no time to read current literature. This results in people operating with knowledge gained upon leaving their educational institution, plus on-the-job information and experience. But they are relatively uninformed about new techniques and developments.

## Fundamental Information Exchange—Validity of Measures and Indices

We need to find better ways to exchange information and to communicate and use research results. This is more fundamental than technology transfer. It requires real research directed at the validity of measures and indices. For example, in the case of using conservative plants for wetlands, questions come up about broad applicability. Can the plant be used in Colorado or California or is it only useful in the Northwest? What is the result of peer review? What are its fundamental foundations?

Whole set of questions need to be addressed, but many of us are using personally developed techniques and procedures or those developed by peers. We need a directed effort that contributes information and uses the previously suggested compendium.

## Monitoring

We need to learn to do better research monitoring using more effective design. We do not know how long to implement monitoring after a project. We need to know much more about monitoring; not only about developing monitoring procedures, but also about how to integrate all these factors. ❑

## Recommendations for Action

# Management Issues

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The management group made the following recommendations for priority actions:

- Develop restoration plans in the context of the landscape (watershed ecosystem).
- Collect available data, ecological histories, social and economic information by available means (corollary: do not get hung up in technology).

  Ample background information often exists. Much information is cheap or free. To develop rational restoration plans, you must know the opportunities in the watershed. You should also know what ecosystems were formerly present.
- Solve agency and jurisdictional turf battles (focus on the resource). For example, state transportation and natural resource departments are often at odds. Yet, between the two, they have the capability to provide a strong natural resource data base.
- Use local citizens groups and government as sources. Work bottom up, not top down. State and federal governments should provide data and technical support. Planning and implementation work best when performed locally.
- Plan for the worst—you will not be disappointed. Floods hurricanes, fires, recessions, lawsuits will happen. Planning for them is cheaper and more environmentally efficient in the long run.
- Start yesterday. We are still losing wetlands, species, ecosystems, open space, and life support systems. Air and water still contain substances inimical to long-term human health, safety, and welfare. ❑

*Recommendations for Action*

# *Priority Ecosystems*

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Without the time or expertise to develop a list of priority ecosystems, this group focused on the process of prioritizing.

While EPA has begun to pay more attention to ecological issues, it has a long way to go. Former EPA Administrator William Riley made great strides in moving the agency in this direction; however, Administrator Carol Browner is expected to go even further, especially since she has named ecological protection as one of her five major themes.

## Information, Information, Information

We need more information. We need a lot more information. But we also need to take action immediately. Permits are coming up, grants are being issued, and we need to choose between restoring one area or another. So while we need more research and want nearly perfect information, we need to somehow get along with what we have, because we cannot afford to wait for five or 10 years to accumulate more data.

We need to get beyond the site-by-site reactive mode. For example, when we have a permit coming up, what do we do? Do we have key sites identified? Will we need to muddle through because we have not gotten ahead of the curve by developing some proactive plans? This returns to the theme of ecosystem planning, watershed planning, and landscape planning.

## Focus on Best Opportunities

We need to focus on our best opportunities. EPA is good at some things, but not good at others. EPA can give money for some things but not for others. We can regulate some things, but others we cannot. EPA needs to focus on situations where we have a reasonable chance to create an incentive or otherwise compel someone to do what needs to be done.

We cannot just look at EPA's comparative advantage. We must look out to see what other people and organizations are doing—what restoration activities are already going on and where. What can EPA do to push the project over the top, add value, and involve others? We need to think about key ecological sites and ecosystems and their potential for restoration.

We must not reinvent the wheel—EPA is famous for this. In determining that we need a list of priority restoration sites, we cannot appoint an EPA committee and take two years to develop the list. Other organizations with ecological protection as their prime mission have already done this work. EPA needs to use that information.

We had unanimous agreement that EPA ought to enthusiastically participate in Bruce Babbitt's call to do a biological survey to give us a better idea of what is left, what is gone, and what could be restored. The survey is still being formulated, and EPA should participate. EPA should not only draw on what is being put together by other groups with more expertise, but also get behind efforts like the state heritage programs. We need to do what we can to support those efforts rather than just passively wait to receive the information or reinvent it ourselves.

## Use Existing Data Bases

The first recommendation on targeting priorities is to look for high priority ecosystems using existing data bases. You may want to add or subtract areas.

What do you do when you must make a decision but the area or state has not been adequately mapped or surveyed? You must issue a permit or decide on giving a state grant for nonpoint source programs—what areas do you steer them toward? Talk to the outside experts—Department of Natural Resources, Fish and Wildlife Service, the heritage programs—and get their informal input if the information is not already assembled.

Reaching out is also related to the need for ecologists at EPA. Ecologists are invaluable as the link between EPA's engineers, chemists, and attorneys and ecologists and biologists in the rest of the world. Sending an engineer out to talk to someone in a state heritage program will likely cause a communication breakdown. Most outside observers do not realize that EPA has relatively few staff members with training in ecology and biology. And we will not be very effective without them.

We need to look for restorable systems and consider the landscape context. However, we need to balance our approach. We should not be restricted to only those sites that are part of a large ecosystem plan, but also try to do something with remnant sites.

We need to assure permanent protection of the site, its surrounding buffer zones, and to the degree possible the overall surrounding landscape. EPA could really use some of its regulatory authority in this area. While we cannot buy up all the land, we might be able to use regulatory authority to affect how land in the watershed or landscape is used and managed. We may need to huddle with people working on these restoration projects and see where we can help. We should focus on situations where EPA can truly offer value added.

## Stick to Our Knitting

In some areas, EPA does not have the expertise, the money, or the regulatory authority. We need to stick to our knitting. We cannot become the world's expert on everything.

We need to look for places where something is already happening. In choosing between two sites of equal environmental value and restoration potential, you might choose the one that has a group of volunteers ready to go or already working on the project.

In addition to receiving information about where restoration groups are active, EPA might benefit from getting some information out to the restoration groups. For example, a restoration group can only work on one site and must choose among three sites with problems with the stream chemistry, riparian zone, and the streambed. On two sites the permit to the dischargers causing the chemical problem will not be up for renewal for several years; on the third site, the permit comes up for review in the next year.

The restoration group may decide to go to the third site. They know that, once EPA improves the stream chemistry, the chances for rapid ecological recovery resulting from restoration of the stream channel and riparian zone will be greater than for streams where stream chemistry will remain impaired for years. ❑