ECOLOGICAL RESTORATION: A Practical Approach

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ABSTRACT

This paper lays out basic concepts and processes for initiating ecological restoration programs. This approach introduces land managers to the practice of ecological restoration. Essential elements of the approach are (1) introduction to ecological problems that restoration can address; (2) rationale for restoration; (3) training in a step-wise process for restoration; and (4) group problem-solving and design of ecological restoration projects to address various problems.

INTRODUCTION

Traditional management of ecological systems focuses on products or services desired by people, with emphasis on marketable commodities. Resource managers learn just enough about ecosystems to maximize the production of these commodities. As a result, ecosystems are over-used and poorly understood.

A different perspective and approach to ecosystem management is required. Resource managers only recently have begun to appreciate the relationship between an ecosystem's condition and its sustainability for human use. Some studies (e.g., Yonzon and Hunter 1991) suggest that regional ecosystem degradation can lead to a decline in production of natural resource commodities. Evidence of widespread ecosystem decline is seen in the growing number of threatened plant and animal species worldwide. Decline is defined as reduced species, and collapse in ecosystem structure, functions and processes (e.g., Haney and Apfelbaum 1990).

Species decline and disappear often over a period of a few years (Wilson 1988). Ideally, ecological restoration should work on mosaics of ecosystems and ecotones over large landscapes, while at the same time paying close attention to localized species populations, isolated habitats, and the smaller levels of ecological organization.

We define ecological restoration as *a practical management strategy that restores ecological processes to maintain ecosystem composition, structure and function.* Successful restoration requires a full understanding of the ecological deficiencies in the ecosystem, a defined course of scientific study through experimental management, and the development of a program for carrying out restoration.

Although, our definition of restoration is human-centered, because restorations occur to satisfy people, our intent is to design restoration strategies that ultimately minimize human intervention. The restorationist must acknowledge the dominance of human values in setting goals for restorations.

Historical conditions are an important reference for understanding the composition, structure and function of modern ecosystems. Information from as many sources possible is important. Ultimately, the experience with the restoration process and site interpretation will contribute to the historical information, because the latter reveals the future trends, while the former provides a basis for understanding the past, present, and potential future.

Experience through experimentation, in the long run, will tell us much more than tree-core data, peat stratigraphy, General Land Office survey notes, and the anecdotes of settlers. We should consider what these sources and the researchers who delve into them have to tell us, however, while engaged in restoration, hypothesis testing, and recalibration of approaches, will better assist us in "saving all the pieces" and set ecosystems on a trajectory that demands the least maintenance from people to continue it.

If people want restorationists to produce, ecosystems that, as far as humanly possible, recreate historical conditions, then recreating historical conditions becomes the goal. Such a goal is often not possible.

We believe the goal of ecological restoration is the establishment of sustainable, productive ecosystems that benefit humans. Analysis of the costs of restoration and its benefits is very different from short-term cost-benefit analyses for commodity production because the latter often does not factor in long-term loss ecological changes and ecosystem deterioration.

INTRODUCTION TO PRESETTLEMENT ECOLOGICAL SYSTEMS

Although we begin here with descriptions of historical ecosystem conditions, in restoration practice we begin with current conditions. Current conditions better define the limits and possibilities of restoration. Often the restoration to the former composition and structure is not practical or economically possible. Restoration will be more successful and less costly when we consider processes at work over an entire region, not just in a project site. The following examples identify some regional issues that should be considered in planning restorations. We draw on our own experiences and data, and on information from the literature.

Prairie Ecosystems

As late as 1860, prairie ecosystems occupied millions of hectares of North America. Elk (Cervus elaphus), bison (Bison), and carnivores with large home ranges (e.g., wolf (Canis lupus), together with wildfire, structured the plant and animal communities (Anon. 1990). Patches of different successional stages were created by the interaction of these regional forces, while small disturbances such as animal burrowing maintained local biodiversity. Settlement reduced the size and complexity of prairies and eliminated animals that needed large acreages (Figure 1). The frequency and pattern of fire, grazing and soil disturbance consequently was changed. The prairie ecosystem is dependent on disturbances to maintain its diversity. However, in the modern landscape, disturbances that once maintained diversity may now reduce it, and new regional conditions make previous disturbances, such as fire and grazing, problematic.

Loss of grazing and a regional fire regime has increased the growth of woody vegetation although haying has substituted somewhat functionally. Restoration of bird populations (e.g. prairie chickens (Tympanus cupio), for example, may be slowed by lack of vegetation structure needed at different points in a life cycle; hedgerows close to the restoration also may harbor predators of ground-nesting birds.

Air pollution and wind erosion of soil are regional problems that may affect restorations by favoring cool-season exotic grasses. Exotic species, such as leafy spurge, infest large regions in the Midwest. Small prairie restorations must withstand a rain of seeds from exotics, unless the exotics are controlled in the larger region. Haying and livestock grazing can encourage exotic plants.

Insects constitute the majority of prairie species. The abundance of each insect species depends on fire frequency and timing. Large prairie restorations allow for a diversity of vegetation patches that are managed to produce an abundance of the most fire-sensitive prairie insects somewhere every year (given good weather).

We distinguish between restoration of a process, and restoration of structure through plantings. Prescribed burning is a process introduced by managers because of its effectiveness and low cost. Mechanical removal, such as haying, brush-hogging, and grazing are also used to discourage trees. Removing trees and brush can alone, bring back a diverse prairie groundlayer, especially on sandier soils.

Where there is no seedbank or vestiges of prairie plants, plantings are necessary. These recreate structure and reintroduce plant species more quickly than unassisted colonization from nearby prairie. For large-scale plantings, we have experimented with combining prairie remnants and planting the uncleaned seed immediately in cropland treated earlier with Round-Up and light discing. Grasses often form the basis for many large-scale restorations. Most small-scale plantings take place in urban or home settings. These small-scale prairie restorations can provide prairie birds and mammals increased habitat opportunities.

Wetland Ecosystems

Wetlands have a dynamic hydrology, chemistry, and biota. Normal hydraulic changes provide low intensity disturbances that maintain diversity. The ecological processes that support wetlands (hydrological, nutrient and sediment cycles) have been altered in agricultural and urban regions. Even wetlands that are directly unaltered are often degraded because of local and regional land uses. A common cause of degradation results from a change in the regional hydrological cycle, causing a rapid swing in water levels as a result of precipitation and changes in rates and quality of runoff. Consequently, native biological communities cannot establish and maintain themselves. Streams in urban and drained agricultural settings especially experience this problem. Hydraulic changes contribute to increased sediments and altered nutrient status. These changes further alter the biological community. Nitrogen and phosphorus adsorbed to soil particles carried into wetlands, along with hydrological changes, encourage development of monocultures of aggressive, persistent plants such as cattails (Typha spp., Apfelbaum 1985) and reed canary grass (Phalaris arundinacea, Apfelbaum and Sams 1987), and decline of native species.

Restoring wetlands requires restoring hydrological dynamics and water quality; quality water is a requisite for quality wetland systems. Channels must be stabilized against erosion, run-off rates reduced, and fire and other techniques introduced to stimulate vegetation recovery. Often seedbanks in degraded wetlands respond quickly to restoration.

Oak Savanna Ecosystem

Oak savannas dominated 50-100 million acres in North America but in the last 150 years have been dramatically reduced. Fire and browsing animals (e.g., elk) maintained an open understory beneath a largely oak canopy; a savanna structure of grassland with scattered trees and brush; or prairie openings within largely forested areas. Plant and animal diversity was high often because of the proximity of three systems: woodlands, prairie, and savanna. A unique assemblage of species was associated with the savanna structure (Chapman 1984, Packard 1993).
Disruptions to this ecosystem included land-clearing and fragmentation, fire suppression,

elimination of browsing mammals, and introduction of livestock grazing (first by pigs, for the oak mast; later by dairy cattle) and exotic plants.

Degradation results from increased shade by invasive woody plants beneath the oak canopy. Open oak canopies permit a relatively full range of light intensity and wavelengths to reach the ground; a subcanopy can significantly reduce it. As shade increases, groundcover plants forbs, grasses, and sedges decrease. With fewer of these fine-rooted plants to hold the soil, erosion begins on slopes with fine textured soils. Run-off is not slowed sufficiently by plant stems, roots, and litter to allow it to infiltrate. Plant diversity, followed by animal diversity declines (Apfelbaum and Haney 1989; Haney and Apfelbaum 1990) is often rapid, (Figure 2).

In contrast, a savanna ecosystem with abundant and diverse ground vegetation retains both water and topsoil after heavy snowmelt and rainstorms. Streams and wetlands associated with high quality savannas exhibit more predictable water level dynamics and higher water quality.

Savanna ecosystem restoration requires an understanding of the potential for a site to recover after following removal of the understory either mechanically or with fire. In some locations, this is sufficient to restore the groundlayer. Savannas are more easily restored on coarse soils than on heavier soils. However, where shade suppression and erosion are long-standing problems, the soil seed bank should be tested for desirable species. Control of exotic shrubs European buckthorn (Rhamnus catharticus), Asian honeysuckle (Lonicera tatarica) and herbs (ie. Garlic mustard, Alliaria officinalis, etc.) that invade savanna is critical.

Watersheds

In the Midwest, undeveloped watersheds function to retard water. This is achieved by 1) nearly continuous upland vegetation cover; 2) numerous isolated wetlands; and 3) headwaters that have no channels. These structures both retain water and slow its flow through watersheds. Beaver dams also slow the loss of water from watersheds. Water in uplands and wetlands is lost through evapotranspiration, to such an extent, that in some streams little flow occurs during the growing season even in normal precipitation years. Because it is held back in the watershed, precipitation infiltrates and may more completely charge groundwater.

Developed Midwestern watersheds loose water much more quickly. In agricultural areas of the Midwest, over 75 percent of the original upland vegetation and over 90 percent of wetlands are gone. Many modern streams were not observed by General Land Office surveyors during the 1830-1860 period. These former wet swales have been incorporated into a web of drains and ditches connected to tile networks in surrounding agricultural fields. The addition of impervious urban surfaces compounds the problems created by these changes.

The overall effect is a dramatic increase in the rate and volume of runoff in Midwestern streams (Apfelbaum, in press, and Figure 3). This destabilizes the soil around watercourses, creating stream channels where they may not have existed, increasing soil and bank erosion, reducing water quality, vegetative cover, and diversity of aquatic plant and animal communities. Banks slump and soil transported from uplands increases the scouring power of the flow, further entrenching channels downstream.

Watershed restoration and changes in surface and groundwater levels can threaten other land-uses. Before undertaking a watershed restoration, know its impacts on neighboring ecosystems. Vegetated filter strips along streams, graminoid cover on banks, revegetated uplands, and restored wetlands will stabilize stream banks and beds, reduce fluctuations in flow, stabilize and diversify the biological community, and retain more water, soil, nutrients, and contaminants in the uplands.

A BASIS FOR ECOLOGICAL RESTORATION

It is important to develop an appreciation for the necessity of restoration. Even after being informed about ecological degradation, some individuals are skeptical about the need to intervene. For a fuller discussion, consult essays by William Jordan and others in <u>Restoration and Management Notes</u> and <u>Environmental Ethics</u>. The objections to intervention with "nature" we have experienced in our projects include:

<u>People, Not Being Part of Nature, Should Leave Nature Alone</u>

> People are separate from nature and should not interfere with it. Ecosystems can take care of themselves. People should not become involved in "natural" processes and tinkering with ecosystems.

<u>People Are Inherently Flawed and Can Only Destroy Nature</u>

> Even if people are part of nature, their current numbers, technology and lifestyle set them apart as nature's destroyer. Moreover, nature has an inherent sacredness which people should not interfere with because our ability to understand nature is fundamentally limited.

Nature Is Inherently Flawed and Will Do What It Wants To

Plants and animals have always gone, and will continue to go extinct. The species and habitats in danger of extinction were on their way out anyway. Other plants and animals will arise and replace them. Therefore, why should we care about changes in the biota? Nature is dynamic, and the changes we are seeing now are part and parcel of its natural processes.

People Cannot Know Enough to Restore Nature

People cannot know what ecological conditions to restore towards. People cannot know whether presettlement conditions, or more recent conditions are most appropriate to model restorations after. Moreover, ecosystems are so complex, it is impossible to comprehend them.

We use four lines of argument and philosophy to explain and justify restoration and implicitly define the kind of restoration:

For Aesthetic Reasons (Beauty)

Nature is beautiful and we should value, preserve and restore the beauty of the Earth, as we would a beautiful or historical building or painting. I, my children, and grandchildren deserve to see everything that nature has to offer, not just the remains of overused and abused ecosystems. Even though dinosaurs are extinct, what would you give to see one alive?

For the Benefit of Human Use (The Utilitarianism of Preserving Species and Ecosystems)

Extinction eliminates the potential for people to tap the genetic reservoirs of life. Nearly all our foods, medicines and fibers come directly from, or are synthetically patterned after natural materials. Providing future generations with the means of life, including the cure for disease, requires the preservation and restoration of ecosystems. If nature breaks down, then human survival is threatened, because we cannot substitute human labor and capital for "free" ecosystem services, such as decomposition, pollination, oxygen recycling, climate regulation, etc. Why would we not intervene in nature if it meant saving ourselves?

For the Reunification of People and their Natural Origins (Human Connection)

The close relationship that develops between people and the land they restore or manage is mutually beneficial. People restore their connection to nature and benignly transform their attitudes towards it, and nature is enhanced as restoration takes place.

For the Benefit of the Species and Ecosystems Themselves

Nature has an inherent right to exist. As human society has evolved, rights have been granted to an ever widening circle beyond the individual, extended in recent times to include trees, birds, flowers and all of nature. People have no right to destroy nature. Instead people should do whatever they can to preserve and restore ecosystems to their most natural state.

Aldo Leopold in The Land Ethic expressed these ideas eloquently (Leopold 1966): "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise. In short, a land ethic changes the role of Homo sapiens from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such. To sum up: a system of conservation based solely on economic self-interest is hopelessly lopsided. It tends to ignore, and thus eventually to eliminate, many elements in the land community [or ecosystem] that lack commercial value, but that are (as far as we know) essential to its healthy functioning. It assumes, falsely, I think, that the economic parts of the biotic clock will function without the uneconomic parts."

These reasons to intervene are based in human values, and because values differ among individuals and groups, not everyone is persuaded by them. In addition, each rationale, if acted on, leads to problems in the intervention itself (Table 1). We believe "Ecosystem Management" is the approach most likely to produce good restoration results. Knowing the short-comings of the approach helps us to avoid pitfalls in designed restoration programs.

Restoration of ecosystems requires the maintenance or alteration of composition and structural components by modifying processes. In all cases, we argue restoration should follow nature's lead, not in order to slavishly recreate an 1850's ecosystem, but to restore an ecosystem's ability to respond to change.

In following nature's lead, we examine several ecological attributes of ecosystems for signs of deterioration from expected conditions (Table 2). Attributes such as species number and relative abundance are predictable based on measurements of repeated patterns and trends in functional and degraded ecosystems. In the most degraded ecosystems, a few species dominate while overall richness is greatly reduced (Whittaker 1975). Differences in species number and relative abundance from the expected patterns based on studies of unaltered areas can often be explained by historic events, often related to human activities. At its simplest level, ecological restoration focuses on biodiversity by attempting to restore opportunities for species of plants and animals to perpetuate themselves.

Processes of ecosystems, such as forest succession or soil development, result from the reactions of plant, animal, and microorganisms to the environment. These functions may be impaired when ecosystem composition and structures are severely altered, or if natural disturbances are removed.

Loucks (1970) and Huston (1979) suggested that species presence and abundance, and trophic relationships can be affected by external processes. Natural disturbances help maintain the diversity and productivity of ecosystems (Picket and White 1985), which creates resiliency to withstand large-scale changes, such as climatic shifts. Thus, at its root level, ecological restoration seeks to re-establish an ecosystem's capacity to maintain species diversity, internal ecological processes, and thereby increase resiliency to changing conditions. It is possible, as illustrated by the examples above, to document some of the changes in ecosystems caused by humans, to measure the degree of change that has taken place, and to prescribe restoration programs that assist nature to reestablish composition, structure, and functions.

RESTORATION GOALS

A restoration program begins by gathering information (Table 3). Complete an inventory of natural resources at the site, and for adjacent lands. Document presettlement and post-settlement land uses and conditions. Historic sources carry their own biases; cross-check information and conditions when possible. Map, describe, and survey and analyze the current ecosystem. Study and obtain data from nearby less altered ecosystems for comparison. Field studies establish current conditions and also help confirm history.

From the information, develop hypotheses about ecosystem composition, structure and functions. Reviewing technical literature and visiting remnant natural lands helps to refine hypotheses. Once understood, the hypotheses (or model) for the ecosystem will help to explain the changes that created the current conditions and the significance of those changes to the ecosystem's future. Devise restoration units which encompass lands that have similar ecological problems and restoration solutions.

Develop goals for each management unit by assessing potential for restoration with reasonable effort, and by specifying its desired future condition. Goals can be quantitative, or qualitative if achieving the desired conditions can be documented by the appearance or written descriptions of the habitat or landscape.

Goals can change as new information becomes available. We develop experiments that test our hypotheses about how species diversity, soil-holding capacity, and other desirable properties of ecosystems are maintained. We undertake small experiments to test a new technique and evaluate the costs of employing it in large-scale restorations. If a goal cannot technically be achieved, except at high cost, it is better to discover that in a one hectare test plot than a 1,000 hectare project. Experimental treatments also determine the most effective approach to restore ecosystems.

We will never fully explain nature, and restoration strategies may not achieve all program goals. In these cases, achieving goals may require a larger scale experiment based on regional ecosystem components and processes. For example, bison have been reintroduced at several preserves in the Great Plains and are being used to test the hypothesis that fire and grazing interacted to maintain a diverse prairie. If the ecosystem cannot be restored at a small site, the decision must be made to expand the site, change strategies, or abandon the goals. However, a decision to scale back restoration goals is a weighty one, since remnant populations of species, already disjunct and stressed, may further deteriorate.

The action plan converts goals into action. A plan often consists of several phases, specific to management units. For example, degraded units may require drastic treatments (remedial phase) that can be costly and time-consuming, but necessary before long-term and low-cost management can begin (maintenance phase). The remedial phase may be mechanical shrub removal in oak savanna, while the maintenance phase may consist of periodic low-intensity burning.

Monitoring programs are often designed last and implemented first. Monitoring provides measurements of program effectiveness. All aspects of the restoration strategy should be known so efficient measurements can document progress toward goals. Measurements of prerestoration conditions serve as a baseline for comparisons with subsequent conditions. Collection of data continues with restoration; restoration methods or goals can be changed if it becomes clear that goals are not being achieved.

Finally, sharing successes and failures advances the science of ecological restoration. It is incumbent upon anyone undertaking a restoration program to keep good records, then write up, publish, or otherwise disseminate their results.

DEVELOPING A RESTORATION PROGRAM

Planning for a restoration program requires time, attention to detail, coordination with and education of landowners (especially adjacent ones), clear understanding of physical limits and potentials of the site, and precise goals. The actual restoration will be strongly molded by the site -- biological and physical conditions, site boundaries, and location. These must be understood in the physical and legal sense. For example, will a wetland restoration affect adjacent landowners, and how? Restoration goals flow from the information, and the program success hinges on how well the goals are formulated and work tasks are implemented.

When restoration sites are small, restoration opportunities are highly constrained. Site location and surrounding land uses determine to a large degree what is possible. On larger sites it is easier to consider the restoration of hydrological processes, for example, modifying flow regimes into and out of the site. We encourage the application of restoration programs over a large geographical unit, if possible. As explained above, this can produce spin-off benefits including lower costs and better restorations.

To organize thinking about restoration planning, we prepared a worksheet which provides a single location for documenting important information required for restoration planning. The worksheet brings major issues and information for restoration planning into an accessible and easily used format.

We use maps, photographs, and resource reports that identify changes and external influences that damaged the ecosystems being considered, and land ownership maps. Combined with specific information from field visits, the planning process progresses rapidly. A growing understanding of ecosystem composition and functions results from completing the worksheet. After developing an understanding of the ecosystem, we define and prioritize restoration and management goals, and define and schedule specific tasks to accomplish the goals. Schedules can be based on quarterly budget cycles; detailed weekly schedules usually are required to implement restoration programs. We express the labor requirements in the schedule to directly calculate budgets.

The worksheet requires that off-site problems be identified. Contact persons and strategies for beginning to address these problems should also be documented. Write everything down; good records are required to track the restoration process.

We use a "management unit" planning approach, even though this can be arbitrary and contrary to ecological conditions. Ideally, a site is managed as a whole, with management practices not reinforcing artificial human boundaries. Management should flow across units, as natural ecological forces did originally. Smaller sites will require a management unit approach, while larger sites may support an integrated landscape approach. Management units are useful as "work units;" that is, specific locations on the ground to which work crews are assigned a task. Burn units are often defined by straight-line fire breaks because igniting fires is safer and cheaper than curving lines.

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Table 1. The Nature of Human Intervention and its Short-Comings.

Impaired Attribute	Nature of the Intervention	Short-comings of the Intervention
Beauty	• Regulation (e.g., air and water emission standards, zoning, etc.) • Landscaping (e.g., performance standards, etc.)	Aesthetic basis for restoration is strongly rooted in human value system and varies greatly with the individual. Consensus standards are difficult to develop.
Species Diversity	• Species Recovery (e.g., Endangered Species Recovery Plans, Transplants, and Reintroductions, etc.) • Restoration Plantings	Costs of single-species recovery are high (e.g., eastern timber wolf), or wasted if species recovers on its own (e.g., bald eagle and osprey). Techniques for multiple-species recovery (e.g., plantings) are in infancy and their level of functioning falls far short of natural ecosystems.
Processes	• Ecosystem Management (i.e., alteration or maintenance of the diverse compositional and structural components of ecosystems by mimicking or establishing the ecologically necessary processes)	Existing information can be incomplete, contradictory, or wrong. Difficult to apply at specific and local level. Approaches can run counter to accepted management practices. approaches may appear to run counter to economic practice or appear politically infeasible.
Human Connection	• Volunteerism • Experiential Education	Lack of expertise can create credibility crisis. Private conservation initiatives may challenge agency authority and appear to question competence. Measured success is diffuse and long-term.

Table 2. Ecological Indications that may Require Human Intervention

Ecological Attribute	Measured Value of Attribute	Indications for Intervention
Total Number of Species	• Overall Species Count by Area • Species Counts in Each Habitat	Species count is lower than expected or has declined for an area or habitat(s). Species count includes high proportion of exotic species.
Relative Abundance of Species	• Numbers of Individuals of Each Species • Proportion of Community in Different Structural Classes (e.g., canopy, large herbivore, etc.)	Number of individuals of each species relative to others is greater or less than expected or has significantly changed. The most abundant species are not those expected, or are exotic species. There are missing or additional structural classes.
Natural Endogenous or Internal Processes	• Rate of Accumulative Processes (e.g., soil development, succession, predation, etc.)	Relative to a fully functional ecosystem, the accumulative processes are reversed (e.g., soil erosion), accelerated (e.g., woody succession in prairies), or halted (e.g., predators removed).
Natural Exogenous or External Processes	• Intensity and Duration of Disturbances (e.g., flooding, draw-down, fire, grazing, windstorm, drought, etc.)	Relative to a fully functional ecosystem, the disturbances are increased in intensity and duration (e.g., hydrological cycle, grazing), or decreased in intensity and duration (e.g., fire). Drought and other climatic disturbances result in simplification of such ecosystems.

Table 3. Ten Steps in a Successful Ecological Restoration.

1. Inventory and map the ecological resources, and describe their current condition.

2. Describe the site's history, and map it where possible (use old aerial photographs, original land survey records and maps produced from them, historical descriptions, oral histories, logging records, 1930's economic land surveys, fire maps, etc.)

3. Develop a hypothesis of how the system works. Review technical literature for related ecological studies conducted in the region; visit nearby natural areas.

4. Develop goals for each management unit by assessing the potential of that unit for restoration with reasonable effort, and specifying its desired future condition.

5. Develop implementation plan to accomplish the goals. Identify and schedule tasks, specify methods, estimate material costs and labor for each management unit.

6. Design a monitoring program to evaluate the success of the restoration.

7. Implement the restoration program. (Develop proposal, obtain funding, establish administrative and field capacity to carry out tasks, install monitoring program, then begin restoration work.)

8. Prepare reports and papers that explain the project and describe results.

9. Periodically evaluate the program by incorporating new information and ideas into the plan, revising goals, and modifying and rescheduling tasks.

10. Communicate with and educate interested and potentially affected parties to provide basic information about and confidence in the restoration process.

Table 4. RESTORATION AND MANAGEMENT PLANNING WORKSHEET

I. Management Unit:___*1*____ and Unit Name:_____*Ft. Snelling Fen/Wetland*_________

II. Existing Vegetation Type (Reference or attach description):___*See Attached*______________

III. Historic Vegetation Type (Reference or attach description):___*See Attached*______________

IV. Plants present that may need focused management attention:

1. *Reed canary grass*
2. *Purple loosestrife*
3. *Cattails*
4. *European buckthorn*
5. *Phragmites*
6.

V. Significant changes in physical (hydrology, drainage, excavation, dredging, sedimentation, or erosion, etc.), chemical (contaminants, nutrients, erosion/sedimentation, agricultural/development, surface water loading, etc.), and biological (other problem species, seed bank depleted, shade suppression of ground cover, dominance by a few species, etc.) components of the unit:

1. *Watershed changes-land development*
2. *Farming*
3. *Watershed acreage reduction-sewered*
4. *Fire suppression*
5. *Overland flow rather than ground water recharge*
6. *Urban deer and rare plant herbivory*
7. *Deicing materials/urban runoff and contaminants*
8. *Road bisects wetland offsetting hydrology*
9. *Wetland fill, ditching*
10. *Chemical changes in water*

VI. Restoration/Management Goals: (Note priority or sequence of events)

( ) 1. *Reduce hydrologic impacts*
( ) 2. *Provide upland biofilter to capture contaminated runoff*
( ) 3. *Reduce invasive shrub cover*
( ) 4. *Reduce sedimentation and nutrient loads*
( ) 5. *Remove road bisecting wetland*
( ) 6. *Increase groundwater recharge in developed uplands and reduce overland flow*
( ) 7. *Reduce exotic plant species*
( ) 8. *Remove fill and debris*

VII. "Monitoring Attainment of Goals" tied to goals above:

Parameter to measure	Method to use	Timing/Frequency
1. *Surface water quality and quantity*	*field meters*	*quarterly/continuous*
2. *Ground water*	*piezometers (nested)*	*continuous*
3. *Vegetation changes*	*permanent transects*	*annually*
4. *Photographic (aesthetics)*	*permanent photopoints*	*quarterly*
5.		
6.		
7.		

VIII. Restoration/Management tasks* tied to goals above:
(* Property boundary surveying, landowner contacts, educational programs, brushing, noxious weed treatment, prescribed burning, install fences, install firebreaks, meetings, monitoring, photography, tours, volunteer efforts, urban wildlife management task, seed collection, planting, propagation and reintroduction of species, press conferences and PR, research, review and refinement of plan, etc.)

1. A. *Brush management*
   B.
   C.
2. A. *Road removal/revegetation*
   B.
   C.
3. A. *Neighbor education*
   B.
   C.

IX. Phasing/Scheduling of tasks:

```
    |-------------R E M E D I A L----------------------M A I N T E N A N C E----------|   Who    Days of
     Q1  Q2  Q3  Q4   Q1  Q2  Q3  Q4   Q1  Q2  Q3  Q4   Q1  Q2  Q3  Q4   Q1  Q2  Q3  Q4    does   effort
         Year 1           Year 2           Year 3           Year 4           Year 5         task   required
1A. |___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___|   _____  _______
 B. |___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___|   _____  _______
 C. |___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___|   _____  _______

2A. |___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___|   _____  _______
 B. |___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___|   _____  _______
 C. |___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___|   _____  _______

3A. |___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___|   _____  _______
 B. |___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___|   _____  _______
 C. |___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___||___|___|___|___|   _____  _______
```

X. Concerns that cannot be addressed by on-site restoration/management:

1. *Power line right-of-way interaction*	4.
2. *Urban water quality*	5.
3.	6.

XI. Site and off-site problems that need to be addressed or considered by others (i.e. land acquisition, property boundaries, wetland creation, permits, railroad, community outreach, volunteerism, etc.):

1. *Water quality*	6.
2. *Channel degradation*	7.
3. *Fertilizers/deicing materials*	8.
4. *Hydraulic volatility*	9.
5.	10.

XII. Contacted persons, agencies: Names, addresses, and telephone numbers:

1.
2.
3.
4.
5.

XIII. Running record of notes of correspondence on the above:
(date, person, point of communication)

1.
2.
3.
4.
5.

Figure 1. Changes in the prairie ecosystem - presettlement to present day.

Figure 2. One phase of presettlement savanna had a canopy of scattered oak, little to variable woody understory, and rich biotic diversity. With fire exclusion, trees and shrubs soon invade, eliminating many of the herbaceous species. Eventual closure of the subcanopy prevents oak regeneration and leads to loss of most herbaceous species and a remarkable decline in breeding avifauna richness. N is number of communities we have studied upon which richness data and degradation pattern is based. Time is estimated (Apfelbaum and Haney 1989).

Figure 3. Linear regression analysis and raw data plots of Des Plaines River discharge at Riverside, Illinois, 1886-1988. Low, median, and high flow data were derived from duration-flow curves for 75, 50, and 10 percentile annual flow levels (Apfelbaum, in press).