CHAPTER 35

ECOLOGICAL RESTORATION

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So far, in this volume and in thinking and discussions about the conservation of biological diversity generally, the emphasis has been on preservation of what we already have. This makes sense. Preservation obviously has a critical role to play in the conservation of diversity. At the same time, however, it is clear that by itself preservation is not an adequate strategy for conserving diversity. At best, preservation can only hold on to what already exists. In a world of change, we need more than that. Ultimately, we need a way not only of saving what we have but also of putting the pieces back together when something has been altered, damaged, or even destroyed.

Consider, for example, that

- vast areas of both land and water have already been profoundly altered by human activities ranging from agriculture to mining and construction and to various forms of pollution;
- barring a catastrophe on the scale of nuclear war, human-caused alterations of natural and wilderness areas will continue indefinitely;
- certain kinds of change—notably changes in climate—are beyond human control, and they in turn will inevitably change even those areas we have succeeded in preserving;
- existing wilderness preserves are often inadequate in size or are suboptimal in shape or design; in many cases, their value as reservoirs of biodiversity could be dramatically increased by relatively modest increases in size, which could be achieved by active reconstruction of communities around their borders;

- numerous species are already on the brink of extinction and their habitats have been reduced to a remnant or perhaps eliminated completely, so that their only hope for long-term survival is the re-creation of their habitat by human beings; and
- the conservation of species ex situ will have little environmental value in the long run unless we find ways of providing habitat for them, often by creating it on disturbed sites.

All these considerations push us, unwillingly it seems at times, beyond a preoccupation with preservation, either in situ or ex situ, as the single strategy for the long-term conservation of diversity and toward a recognition of the importance of an active role for our species in reversing change or repairing damage. Unless, for example, we are prepared simply to write off disturbed lands as potential contributors to diversity, we are going to have to take seriously the problem of increasing diversity on these lands. Similarly, the inevitability of further change, including changes in climate, clearly implies that in order to preserve many communities over the long haul we are going to have to learn not only how to manage them but even how to move them around (Jordan et al., in press). And this brings us to the area of environmental healing, or ecological restoration, which is the subject of this section.

PIONEERING RESTORATION AT THE UNIVERSITY OF WISCONSIN-MADISON ARBORETUM

The starting point for this discussion will be the experience of the University of Wisconsin-Madison Arboretum, where research on restoration of ecological communities native to Wisconsin and the upper Midwest has been under way since 1934. Here, under the early leadership of Aldo Leopold and John Curtis, intensive restoration has been carried out on several hundred hectares of land, most of which had been seriously degraded by farming, logging, and sporadic development during the preceding century. Gradually, 40 hectares of tallgrass prairies have been restored on degraded pasture and plowland. A small xeric prairie has been created on an artificially constructed limestone outcropping. Red and white pine forests and boreal forests have been established on old pasture sites, and two types of maple forests are being developed by underplanting existing oak forests in which the understory had been depleted by grazing. The early stages of this effort were carried out by Civilian Conservation Corps crews working out of a camp on the site between 1935 and 1941. More recent work has been carried out by University of Wisconsin-Madison researchers and by the Arboretum staff. In general, the intensity of the restoration effort declined dramatically after 1941, though work continues, and indeed the need for ongoing restoration and management is one of the fundamental lessons that has emerged from the Arboretum's experiences.

Overall, this has been a pioneering effort, and the Arboretum's collection of restored and partially restored communities is now the oldest and most extensive of its kind anywhere in the world. Even more to the point, however, because of the Arboretum's experience, it is possible to make a number of observations about

the nature of restoration, about its potential and its limitations as a strategy for conserving biological diversity, and about the environmental and social conditions under which it is likely to be feasible.

TECHNICAL, ECOLOGICAL FEASIBILITY

The first lesson that one might derive from this experience is that it is indeed possible, at least under certain circumstances, to re-create reasonably authentic replicas of some native ecological communities (Blewett, 1981). For example, the Arboretum's two restored tallgrass prairies (Curtis and Greene prairies) now include areas believed to resemble quite closely prairies native to the area—at least with respect to floristic composition. In other words, most of the appropriate vascular plants are present; they are present in more or less the right proportions and associations; and the number of inappropriate plants—that is, exotics or plants not native to the tallgrass prairies of this area—is small.

On the other hand, there are large areas on these prairies where ecological or historic authenticity is relatively low and where various exotic species are abundant. Certain of these species have proved to be extremely difficult to remove or control. Some have turned out to be capable of invading the more or less intact prairie community, often at the expense of the native plants. As a result, it is now abundantly clear that the problem of dealing with exotics is an ongoing one and that the struggle will in many instances be unending. Undisturbed natural communities are also vulnerable to invasions by exotic species but, in general, probably less so than communities in the process of being restored. Without doubt, this has turned out to be a major problem facing restorationists.

In addition, the restoration program at the Arboretum has strongly emphasized revegetation, far less attention being paid to the reintroduction of animal species. This is frequently the case in restoration and land reclamation projects, since the assumption is often made that the appropriate animals will find their way into the community once it has developed to a certain point. But this does not always happen for complex reasons that include the size of the communities, their uneven quality, and their isolation from existing animal populations. An instance of this now appears to have occurred in the Arboretum's restored southern maple forest, where ommission of an ant species that normally aids the dispersal of the seeds of certain herbaceous plants, such as bloodroot *(Sanguinaria canadensis)* and wild ginger *(Asarum canadense),* has resulted in the development of these species into peculiar, dense patches (Woods, 1984).

A related problem with restored communities generally is their small size, which can directly influence their ecological quality. Certain animals, for example, may not inhabit restored communities simply because these communities are often too small. This is a major reason why few if any restored prairies include buffalo, for example. At present, the prairie at Fermilab in suburban Chicago is probably the largest restored tallgrass prairie in existence (Nelson, 1987). Of course, this nearly 240-hectare prairie is still very small in comparison to the millions of hectares of prairie that existed in this area at the time of European settlement, and its ability to support populations of large native animals is at best problematic.

In addition to the more conspicuous defects in the composition of restored communities, there are numerous features, such as soil structure and chemistry, composition of soil flora, populations of less conspicuous animals (including insects), and various aspects of ecosystem function, that in many instances may not be authentic. Only rarely have these been studied in any detail.

On the positive side, however, the Arboretum's restored communities have brought back into the landscape numerous plants and animals that had become rare or had even been eliminated locally. The entire project certainly represents an enormous contribution to what might be called the native diversity of the Madison area. The Arboretum's restored tallgrass prairies, for example, are now among the largest prairies in Wisconsin, a state that had some 4.8 million hectares of prairie and savanna at the time of European settlement (Curtis, 1959). These prairies alone include more than 300 species of native plants. Some of them, including plants such as big bluestem grass *(Andropogon gerardi),* compass plant *(Silphium laciniatum),* and yellow coneflower *(Ratibida pinnata),* were extremely abundant in presettlement times, often dominating whole landscapes, but were virtually eliminated from the area by the time the restoration efforts at the Arboretum began. These now flourish in the restored communities, which also provide habitat for numerous rare species. Examples from the Arboretum's collection include such rarities as the white-fringed orchid *(Habenaria leucophaea),* prairie parsley *(Polytaenia nuttallii),* smooth phlox *(Phlox glaberrima),* and wild quinine (*Parthenium integrifolium)*—all considered threatened or endangered, at least for the state. In general, the Arboretum itself probably has more biological diversity than any other area of comparable size in the state. This is due largely to the presence of the various restored communities.

In short, the Arboretum's experience shows that restoration of some native communities may be technically feasible under certain conditions. The ecological quality of the resulting communities may vary, but under proper conditions, it may actually be quite high, and restored communities may often resemble the historic community chosen as a model quite closely, at least in floristic composition.

SOCIAL, ECONOMIC FACTORS

At the same time, the experience of the Arboretum raises a number of questions about the cost of such projects and the social, political, and economic feasibility of carrying them out. Thus, in considering the environmental significance of the Arboretum's restoration efforts, one should keep in mind that these efforts have been carried out under conditions that clearly limit their relevance to other situations. These conditions include first of all the fact that the Arboretum itself is part of a major university and that its work has been performed primarily for scientific and academic reasons. In other words, from the very beginning, this effort has benefited from its academic setting and has been justified as an experiment or as a way of creating communities for research, rather than as a way of coping with environmental, much less economic, problems.

The second set of conditions that have contributed to the success of the Arboretum project were those directly related to the economic and ecological con-

ditions of the 1930s, notably the Great Depression and the Dustbowl. Together, these national calamities provided conditions (specifically, cheap land, free labor in the form of the Civilian Conservation Corps, and an incentive for ecological restoration) that proved crucial to the development of the Arboretum, but that have also reduced its value as a model for carrying out restoration projects in the real world outside academia. This point carries us outside the little world of the Arboretum to the larger world, where we have to ask a crucial question: What good is restoration? Is it likely to prove merely an academic pursuit or a pastime for environmentalists who happen to be interested in an unusual form of gardening? To just what extent and under what conditions can restoration be expected to contribute in a significant way to the conservation of diversity?

These questions have not yet been dealt with systematically, as far as I am aware. But it is important that we begin to take them seriously. In general, given the interrelatedness of everything on Earth and the inevitability of change, it would seem that an ineluctable logic argues for the importance of restoration as part of any comprehensive strategy for the conservation of biological diversity. Critical as it may be as part of such a strategy, preservation has serious defects. Basically, it is a one-way strategy that offers no way of responding to change or recouping losses. By itself, any such approach is clearly inadequate because in a changing world the quality of the environment is ultimately going to depend not simply upon the amount of land we manage to set aside and to preserve but upon the *equilibrium* we are able to maintain between the forces of destruction—or change—on the one hand and the forces of recovery on the other. All things considered, and despite its various limitations, it seems likely that restoration will ultimately play an important role in determining the position of this equilibrium.

This being the case, the questions raised above and a whole host of corollary questions and issues take on a great deal of urgency. Can we restore ecological systems? And if so, how authentic will the results be? Which communities lend themselves to restoration, and which are likely to prove more difficult—or even impossible—to restore? To what extent can we hope to re-create communities specifically designed to provide habitat for rare and endangered species? What needs to be known in order to restore a system effectively—and efficiently? What is the state of the art for the restoration of various communities, and what currently limits the effectiveness of restoration techniques for these systems? What sorts of research need to be undertaken in order to refine these techniques?

Beyond these questions about the technical feasibility of restoration, there are the various social, economic, and political questions: How much will it cost? Who will be expected to pay for it, and why? How will the costs compare with those of preservation or with the natural recovery of disturbed systems? What incentive will society have for restoring naturally diverse communities rather than for simply reclaiming land for some other purpose such as agriculture? In general, what incentives can be found for restoring communities—incentives that will ensure that restoration is actually accomplished and that its potential for contributing to biological diversity is effectively exploited?

In fact, there are a number of such incentives, including some traditional ones such as the creation of habitat for fish and game and the use of prairies as pasture

and rangeland. There are also important aesthetic incentives in park and wilderness management and in landscape architecture.

But restored communities may well have other economic values that have not yet been fully identified or widely recognized. Examples include development of wetlands to control water distribution and quality (Holtz, 1986), of prairies to rehabilitate soils degraded by agriculture (Miller and Jastrow, 1986), and of forests as part of a program of sustained-yield timber production (Ashby, 1987). Applications such as these at least suggest ways in which restoration might eventually prove critical as a way of reintegrating native communities into the economies of developed nations, in the process returning them to the landscape on a large scale.

These questions are addressed in the four chapters that follow. The first two are devoted mainly to defining the state of the art of ecological restoration for two community types. In the first of these, Chapter 36, Joy Zedler discusses restoration of a temperate zone community, the tidal wetland. In Chapter 37, Chris Uhl addresses the much-neglected subject of tropical forest restoration. The following two chapters turn to the more socially oriented aspects of the business of restoration. In Chapter 38, John Cairns looks at disturbed lands as opportunities for increasing local and regional biodiversity through restoration. In Chapter 39, John Todd presents some ideas about creating a social, political, and economic context for restoration projects.

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