Life Support

Ensuring the health of the planet's aquatic ecological system is a delicate balancing act.

BY JOHN CAIRNS JR.

Where there is no vision, the people perish.
Proverbs 29:18

The basic material needs of humans are food, shelter, and freshwater. Only a tiny fraction of the planet's water is fresh, and a significant portion of this fraction is presently locked up in polar ice caps and glaciers.

Constant reuse of the finite supply of freshwater is made possible by the biota of aquatic ecosystems, which are most productive when they are robust and healthy. Since the health of the aquatic ecosystem is closely coupled with the condition of the adjacent land, however, ensuring this healthy state requires constant monitoring of both land and water ecosystems.

Aquatic ecosystems are damaged in a variety of ways—for example, through bad land management; drastic alterations of the hydrologic cycle by dams, irrigation, and destruction of wetlands; anthropogenic wastes; introduction of exotic species; biotic impoverishment; and erosion of adjacent land masses. Since humans depend upon ecological and technological life-support systems, it is essential to maintain an optimal relationship between the two so that neither damages the other.

Abundant case histories show that aquatic ecosystems can be successfully restored to a healthy state, but the worldwide rate of damage still exceeds the rate of restoration by a substantial margin. Maintaining a balance between the rate of damage and the rate of restoration is a minimal requirement for sustainable use of the planet. If quality of life is to be maintained in the 21st century, as populations and affluence increase, restoration must exceed damage by a substantial margin.

The National Research Council defines restoration as the return of an ecosystem to a close approximation of its condition prior to disturbance.[1] In restoration, damage to the structure and functions of the resource is restored.

Recreating the form—the structure—without the functions or recreating the functions in an artificial configuration bearing little resemblance to a natural resource does not constitute restoration.

Value Systems

The functions of ecosystems that are perceived as valuable to human society—flood control, production of food and fiber, good water quality, atmospheric gas balance—are crucial components of the restoration planning process; otherwise, society would almost certainly neither restore damaged ecosystems nor preserve and maintain them once restored. Therefore, we must determine the optimal balance between these human values and purely ecological values, such as population interactions, nutrient cycles, and energy transfers throughout an ecosystem. In so doing, we can greatly increase our environmental literacy in both areas.

If the purely ecological values are slighted, the restored system will not likely be self maintaining. And if the human values are slighted, the project is less likely to be funded.[2]

Problems of Scale

Whenever feasible, ecological restoration should be carried out on a large scale—encompassing at least an entire watershed. Restored systems on a large scale are more likely to be self-maintaining than systems that are small or fragmented. From an ecological standpoint, planning at the landscape, or better yet bioregional, level therefore makes good sense.

As a general rule, the larger the system, the larger the number of stakeholders who, in turn, are likely to increase the level of contention and conflict. But this situation is not inevitable. Consider, for instance, the restoration of the large Kissimmee riverine-floodplain system, which needs to be understood in the larger context of the effort to restore the Florida Everglades. The Kissimmee was once a broad, meandering 103-mile-long (166-kilometer) waterway that drained an upper basin consisting of a chain of lakes. In 1961, the U.S. Army Corps of Engineers began a channelization effort that transformed the river into a deep, unshaded 56-mile canal. The channelization of the Kissimmee River alone drained 34,000 acres (13,800 hectares) of floodplains, wiping out 5 billion small fish and 6 billion shrimp.[3] Birds and vegetation also suffered. Not only were the spatial and temporal scales large in this restoration project, but three governors of Florida were involved in the initial stages, and subsequent governors were key to continued success in maintaining the partially restored system.

Another success story is the cleanup of the Thames River estuary in the United Kingdom. The Thames estuary fishery started to decline about 175 years ago. By the 1950s, the only fish able to survive in the most polluted reaches were eels. Between 1967 and December 1973, however, a total of 73 species were recorded, and isolated captures from December 1973 to March 1975 increased the total to 80. Improved waste treatment and management probably accounted for much of the improved ecological conditions, which required the cooperation of numerous stakeholders and the balancing of conflicting values such as sewage treatment, water quality, fish and wildlife habitat restoration, navigation, and upland development.

Paying the Piper

Garrett Hardin's classic paper, "The Tragedy of the Commons," published in *Science* magazine in 1968, illustrates the problem of protecting communally used lands from damage.[4] A few individuals may benefit substantially from overuse of the commons—by grazing too many cattle on it—but the costs of the damage and restoration are distributed over society as a whole. Unrestricted use of aquatic ecosystems is a ubiquitous phenomenon, and those who profit from abusing them, such as polluters who have used natural systems and lakes to carry off their wastes, generally evade paying for restoration.

The penalties of an unmanaged commons have been recognized for years, but the funds for correcting abuse through ecological restoration have been difficult to obtain.[5] It seems society is prepared to pay the cost of maintaining and restoring the technological infrastructure but is extremely reluctant to restore the ecological infrastructure. This mind-set is curious but understandable—potholes in highways are more easily observed than comparable damage to ecosystem integrity. Funds for "developing" natural systems—for example, displacing the biota with shopping malls, housing developments, and highways that shave a few minutes of commuter time—have always been plentiful compared with the funding to restore ecosystem damage. What is especially lacking is the will to fund aquatic ecosystem restoration. If funds have not been available in the current era of global prosperity, the prospects of such funding seem dim during the economic downturn we are likely to face in the near future.

Reasons to restore aquatic ecosystems range from improving the quality of water for consumption, agriculture, and recreation to providing habitat for fish, wildlife, and endangered species. Though the popular press carries stories on the crisis of species extinction,[6] the general public is less aware that water for irrigation and other agricultural uses is becoming exceedingly scarce throughout the globe.[7]

Moreover, the implications for human health are great. Evidence is mounting that environmental contaminants are implicated in developmental and neurological damage to human offspring through exposure to toxins in wildlife, particularly top-predator populations in aquatic ecosystems.[8] As the global economy rapidly spreads, so too will industrial contaminants, and the human health effects almost certainly will snowball. The process of restoring aquatic ecosystems therefore should include reducing contaminants that affect human health and the environment.

Yet the literature on who should pay for ecological restoration is sparse. One study that summarized the literature on paying for ecological restoration devoted considerable attention to the methods for evaluating the costs and benefits of restoration.[9] Clearly, many funding sources are possible, all of which can be used to some degree in almost any area. Due to a high degree of site specificity, however, only a few of the sources may be available at one site. In addition, water—particularly in riverine systems—is likely to cross a number of political boundaries, large and small, so restoration will require funding from several sources.

The Ticking Clock

Human society is struggling with other issues that involve the commons and the biosphere.[10] Each year, for example, the U.S. Congress and the president find themselves in a standoff over peacekeeping funds, leading some to wonder whether time is running out for peacekeeping efforts.[11] One might also wonder if time is running out for ecological restoration.

Ecological restoration is primarily an ethical issue.[12] If humans damage the biosphere, shouldn't they accept the responsibility of making whatever restoration is possible? How do we persuade them to pay for restoration? The following items are potential building blocks for a rationale for ecosystem restoration.[13]

- Society must protect the environment and enhance the benefits that ecosystems provide.
- Society's practices, rather than its statements, are the best indications of its guiding beliefs about its relationship with the environment.
- Documenting the full cost of ecological restoration may well serve as the best deterrent to further ecological damage.
- Situating ecological restoration projects in each ecoregion, and preferably in each major area of the country, will provide easily accessible demonstrations for local citizens; this visibility increases environmental and restoration literacy.

Setting Goals

Unless the term *restoration* is clear, communicating goals to the general public is difficult. Goals should therefore be broad-based and measurable. The lack of stated goals is surprisingly common despite the obvious need for them in the attempts to restore ecological damage.

Goals might range from restoring habitat for an endangered species in a hot spring to restoring Siberia's Lake Baikal, the largest freshwater lake in the world. Each goal is reasonable but will require different parameters to achieve success. If the goals are not explicitly stated, measuring success is impossible.

Perhaps fear of the results of measuring success accounts for the curious reluctance to set goals. The National Research Council has proposed national goals for the restoration of rivers, lakes, and wetlands that are quite specific, setting the amount and percentage of aquatic restoration as well as a target date.[14] Examples include:

- Restoring 40,000 miles (64,000 kilometers, or 12 percent of the U.S. total) of river-riparian ecosystems by 2010.
- Restoring wetlands at a rate that offsets any further loss of wetlands and contributes to an overall gain of 10 million wetland acres (4 million hectares, or 10 percent of the wetland acres lost in the past 200 years) by the year 2010.

Government policymakers have been noticeably reluctant to discuss modifying or implementing these goals. If aquatic ecosystem restoration is to proceed in a systematic and orderly fashion, explicit goal setting is essential. The news media and the general public need to be aware of goals, as well as progress toward achieving them, so others may emulate these efforts.

Quality Control Monitoring

Monitoring is surveillance undertaken to ensure that previously established goals or quality-control conditions are being met.[15] A long-accepted practice in the field of ecotoxicology is to develop feedback loops that provide information about the condition of an ecosystem.[16] Surveys assessing the structure and function of aquatic communities that provide early warning of deleterious conditions are an illustrative example of the type of information gathered.[17]

Feedback loops are the norm in hospital intensive-care units, industrial product monitoring, and outer-space vehicles. Without them, corrective action is problematic. But these practices are not well established in restoration of aquatic ecosystems. Failure to develop feedback loops in the dynamic process of aquatic ecosystem restoration is a significant obstacle toward achieving long-term goals.

Ideally, restoration monitoring should be carried out for a specified period, at least until the ecosystem is self-maintaining.[18] Prudent management requires some quality control information, however, even after self-maintenance is achieved, to provide early warning of adverse changes.

Most complex systems have a certain amount of redundant information. For example, there may be a number of aquatic organisms present that process detritus or perform other comparable functions, or a species of prey may have numerous predators. In one sense, this information is redundant; in another, it provides evidence on the number of backup components if one is lost.

The multiple confirming lines of evidence from this redundancy, however, reduce the probability of false positives and false negatives, thus justifying the added cost of the redundant information. A false negative would indicate the restoration was on track toward the designated goals when, in fact, it was not. A false positive would indicate that unacceptable quality conditions existed and the project was not on track when the deviation was due to normal variability or some other ecological attribute that had not been adequately documented. In both cases, the error is due to extrapolations from an inadequate information base. A more adequate, and more costly, base produces less erroneous information because information viewed as redundant can also be viewed as confirming.

Building redundant information into a restoration project helps ensure the project's reliability. Although the cost of adding redundancy can be significant, the cost of acting on inadequate or unreliable information is almost certain to be higher.

Living Legacy

Every generation receives a natural and cultural legacy in trust from it ancestors and holds it in trust for its descendants.[19] Environmental law professor Edith Brown-Weiss stresses the need for intergenerational fairness in water resource use; she says that each generation should protect the integrity of its water resources for the next generation.[20] Hydrologist Luna Leopold also argues for ethos, equity, and fairness in water resource use.[21] And I have argued elsewhere that ecological restoration is a major component of sustainable use of the planet.[22]

Not everyone is happy with the concept of ecological restoration, however. Some have criticized it as an unethical and immoral attempt to substitute "fake" natural systems for nature. Philosopher Eric Katz, for instance, deplores ecological restoration as an unwarranted intervention in natural systems and a form of human domination.[23] He further argues that ecological restoration based on functional attributes destroys the ontological identity of the area being restored.[24] Philosopher Robert Elliot has even condemned perfect restoration as a morally wrong process that replaces "real" nature with a "fake."[25] These critics propose leaving nature to develop as it chooses rather than as humans choose.

Conservation biologist Michael Soule asserts that nature is now assaulted by human, physical development as well as covert ideological and social actions.[26]

The debate is ongoing and is unlikely to be settled anytime soon.

Human Touch

Since much of the damage to aquatic resources was inflicted, intentionally or not, by humans, humans should be responsible for helping restore ecosystems to a healthy state. This is not just an ethical or esthetic stand, however; it is also an economic one. Restoration benefits people as well as biota. From a sustainability standpoint, ecological restoration of damaged aquatic ecosystems makes them more suitable for colonization and habitation by a greater variety of organisms than in their degraded state. Successful restoration enhances both reliability and abundance of ecosystem services essential to both nature and human society. The natural legacy for future generations will be more desirable if damaged ecosystems and anthropogenic artifacts—such as shopping malls, highways, and urban sprawl—are replaced, to the degree possible, with naturalistic assemblages of plants and animals.

Restoring aquatic ecosystems will normalize the hydrologic cycle to the benefit of both aquatic creatures and human society.

Finally, ecological restoration demonstrates an ethical responsibility for anthropogenic damage. It is indeed a pity the damage occurred, but making the ecosystem acceptable to its former inhabitants is preferable to neglect.

Most people, especially those who value recreation in natural systems, hope for a better quality of life. Ensuring quality of life demands that the rate of ecological restoration must exceed the rate at which ecological damage occurs. This is especially true because damage and restoration often occur at different temporal and spatial scales. An accidental spill of a hazardous material can severely damage an aquatic ecosystem in minutes or hours, but restoration to an approximation of its predisturbance condition can take years or decades.

Sustainable use of the planet requires that ecological damage be prevented whenever possible and that it be restored when damage occurs. We must protect the planet's ecological life-support system. If we can ensure that the rate of restoration of ecosystems exceeds the rate of damage, future generations will hold us in their debt.■

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NOTES

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