GUEST EDITORIAL

Protection and Restoration: Are We Having an Effect?

Katherine A. McGraw and Ronald M. Thom

What we need is a new Intichiuma,[1] *a way of linking the interests of the natural landscape with the interests and ambitions of human beings who are, as the Aborigines realize and express in their myths and rituals, responsible for its beauty and well being. Any attempt to resolve environmental problems in the other way, by placing nature and culture in opposition, or by demoting human culture to mere equality with the rest of nature, denying its shameful transcendence over it, will inevitably fail. But I believe that if we accept this and the responsibility it entails and make the carrying out of this responsibility an occasion for confronting shame, for learning, and for celebration, we stand a fair chance of succeeding. . . . The great value of restoration is that it provides a basis for this new* Intichiuma, *with its double benefit of environmental healing and deepened understanding and caring.*
—William R. Jordan III, *The Sunflower Forest* (2003, 203)

The impetus for this special theme grew out of discussions that began several years ago in the NOAA Restoration Center (a division within the Office of Habitat Conservation, U.S. National Oceanic and Atmospheric Administration) and resulted in a panel session titled "Protection and Restoration: Are We Having an Effect?" at the 2007 meeting of the Estuarine Research Federation (November 4–8, 2007, in Providence RI). The session was developed with the intent to publish a special journal issue with the same theme. The all-day session was divided into three parts: reflections on estuarine restoration by veteran practitioners; regional perspectives from those actively engaged in habitat restoration on different U.S. coasts; and new kinds of technologies and tools. Twenty invited speakers addressed the question "Are we having an effect?" with our habitat restoration efforts in coastal and riverine areas. A subsequent call for papers for the special volume resulted in over a dozen manuscript submissions, most of which were selected for peer review by experts on the various topics covered.

Exploiting the Environment

In trying to answer the question "Are We Having an Effect?," it is perhaps instructive to reflect briefly on the history and stages of restoration, why we are doing it, and how it has changed over the years. Humans have altered their environments for thousands of years for basic survival needs (for example, agriculture, harvesting trees for firewood, diverting streams), and to increase their quality of life. There are examples of habitat alteration being accomplished in ways that are both environmentally sustainable, such as the Papua New Guinea highlands (ca. 10,000 B.C.E. to present) and the Tokugawa era in Japan (1603 to 1868 C.E.) and unsustainable, such as by the Mayans of the Yucatan Peninsula (250 to 900 c.e.) or the people of Easter Island in the Pacific (ca. 500 to 1600 C.E.) (Diamond 2005, Peacock 2008, Somma 2008, Sponsel and Casagrade 2007).

In more recent times, and especially since the industrial revolution, exploitation of resources and poor land use practices have resulted in unprecedented destruction and fragmentation of habitat and loss of species. In the United States, for example, it is estimated that loss of wetlands has been more than 50% since colonial times (HJHCSEE 2002), and about 30% of coastal waters are considered to be in poor overall condition (USEPA 2008). Although it is estimated that the United States gained about 23,800 ha of wetlands per year between 1998 and 2004 (Dahl 2006), about 161,000 ha of coastal wetlands were lost, mostly because of coastal development (Stedman and Dahl 2008). In the Gulf of Mexico, the hypoxic area, or dead zone, has more than doubled over the past 22 years, from about 9,880 km^2 in 1985 to about 20,500 km^2 in 2007 (Rabalais et al. 2007), with a maximum of about 22,100 km^2 in 2002 (Rabalais and Turner 2006).

Some of the most endangered species are mollusks. Although the United States has one of the most diverse arrays of gastropod fauna in the world, freshwater snails

1. Sacred ceremonies performed by some Australian Aboriginal peoples, directed toward plants, animals, and natural phenomena with totemic significance (Definition from Encarta® World English Dictionary [North American Edition] © & (P)2009 Microsoft Corporation. Developed for Microsoft by Bloomsbury Publishing Plc)

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are one of the most imperiled groups in North America, and 9% are thought to be extinct (Johnson 2003). In the United States and Canada over 72% of native freshwater mussel species are extinct, endangered, or in need of special protection (Williams et al. 1993, Abell et al. 2000). In estuarine waters, the loss of oyster reefs in the United States is estimated to be about 90% or more in many bays (Beck et al. 2009). In addition, about 37% of native freshwater fish species in the United States are imperiled or in danger of extinction (Stein et al. 2000).

Environmentalism in the United States

The environmental movement in the United States has gone through several phases, beginning with preservation and protection of pristine areas. Then, in the mid-1900s, people began to recognize the impacts of environmental contamination on human health. Present-day efforts involve both large and small organizations of citizens in restoring local habitats and ecosystems in urban, suburban, and rural areas (for example, "community-based" restoration). Two early activists who recognized habitat degradation as a problem and pursued conservation and preservation methods to address adverse human encroachment were John Muir (1838–1914) and Aldo Leopold (1887–1948). Muir is credited with saving many wilderness areas, including parts of the Sierra Nevada mountains and Yosemite Valley, and was instrumental in the establishment of Yosemite, Sequoia, Mount Rainier, and Grand Canyon National Parks; hence, he is known as the "father of our national park system" (Sierra Club 2010). Aldo Leopold, founder of the Wilderness Society, took the idea of wilderness conservation a step further with his "land ethic," which set forth the idea that humans should enlarge their concept of community and form a new cooperative relationship with nature based on respect, care, and responsibility for land and all the nonhuman elements existing in it, including plants and animals (Aldo Leopold Foundation 2010).

Women have figured prominently in the environmental movement the in the United States and other countries. In 1962, Rachel Carson redefined environmental awareness and is credited with launching the modern U.S. environmental movement with her book *Silent Spring*. Her book served to galvanize people concerned about the effects of contaminants (especially DDT) on wildlife as well as on human health. This was in the same vein as some earlier women in the late 1800s and early 1900s—Caroline Bartlett, Mary Eliza McDowell, Alice Hamilton, and Ellen Shaw Richards—who linked human health concerns, such as garbage, sewage, and unsanitary neighborhood conditions created by industries, with the degradation of their local urban environments (Palamar 2008). In the last three decades more women, such as Lois Gibbs and Sandra Steingraber, have been instrumental in leading movements linking environmental health concerns, poverty, and environmental justice to the need for ecological restoration in urban landscapes, as well as in more "natural" areas (Palamar 2008). In Africa, the Green Belt Movement, led by Dr. Wangari Maathai, is a women's society established to "empower communities worldwide to protect the environment and to promote good governance and cultures of peace." That movement began as a tree-planting program to restore trees and prevent soil erosion (Green Belt Movement 2006).

As public awareness and concern grew in the United States about environmental problems, the U.S. Congress passed legislation to address environmental destruction and pollution and to protect habitats and species: the Clean Water Act, the Clean Air Act, the Endangered Species Act, the National Environmental Policy Act, the Oil Pollution Act (OPA), the Safe Drinking Water Act, the Fisheries Conservation and Management Act (better known as the Magnuson Stevens Act), and the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These and other federal mandates form the basis for much of the restoration conducted by U.S. federal agencies. For example, response and cleanup activities for the April 20, 2010, Deep Water Horizon oil rig explosion and spill in the Gulf of Mexico (also known as the "BP spill") will be pursued under the OPA; then liability will be determined, and responsible parties will be held accountable for environmental and economic destruction that resulted from the spill. Environmental assessments will also be conducted under the Natural Resource Damage Assessment (NRDA) process, and restoration (paid for by the responsible parties) will eventually be undertaken to help restore damaged habitats.

In the last 20 years more people have become keenly aware of the plight of our environment, environmental justice issues, and the interconnectedness of human well-being and environmental health. Many have joined together to form organizations and community groups to not only preserve and protect pristine habitats, but also to restore those that are in various states of degradation (The Sierra Club, The Nature Conservancy, World Wildlife Fund, National Wildlife Federation, National Wildlife Federation Foundation, Trout Unlimited, Earthcorps, etc.). Some are dedicated to preserving and restoring freshwater streams (for example, American Rivers), while others focus on coastal and estuarine habitats and ecosystems (for example, Restore America's Estuaries, Coastal America).

Many of the U.S. organizations and foundations listed above receive grants from the NOAA Restoration Center (RC) for their projects. The RC was founded in 1990 in response to the Exxon Valdez oil spill in Alaska and is devoted to restoring the nation's coastal ecosystems and preserving diverse and abundant marine life. Over this 20-year period, the NOAA RC has funded more than 2,700 projects in various habitat types at a cost of over

$316 million in federal funds, restored, created, enhanced, and protected over 38,000 ha of habitat, and opened up over 4,800 km of stream and river habitat via removal of dams and other obstructions to water flow.

Restoration Ecology and the Need for Scientific Studies

Along with these ecological restoration efforts, a new science has emerged. "Restoration ecology," a term coined by William R. Jordan III and Keith Wendt, is a learning-by-doing approach to understanding ecological principles. The organized study of restoration activities and projects, and a rigorous experimental approach, can help provide guidance and new methodologies to practitioners. In addition, many scientists are no longer just studying restoration effects, but are actively involved in many restoration projects, interacting with groups of restorationists and providing current information to help ensure the success of their projects.

Terminology used in environmental resource management has also evolved. The terms *restoration, preservation, rehabilitation, protection, mitigation,* and *conservation,* sometimes used interchangeably, have been better defined to distinguish between the various activities (National Research Council 1992, Society for Ecological Restoration International 2004). Although restoration may overlap with or include some other types of resource management, it is seen as distinct from them by many practitioners. For example, Jordan (2003, 22) defines restoration very broadly as "everything we do to a landscape or an ecosystem in an ongoing attempt to compensate for novel influences on an ecosystem in such a way that it can continue to behave or can resume behaving as if they were not present." However, he further states that restoration is distinct from other restorative forms of management in that it implies bringing a whole system back to a former condition, not just a part of it (e.g., not just a certain species or plant), including those features we may find "uninteresting, useless, ugly, repulsive, or even dangerous" (Jordan 2003, 22).

The amount of restoration that needs to be done is daunting. In response, tens of thousands of restoration projects are currently underway or have been implemented worldwide in the last decade, and many more are planned. An increasing proportion of these are more ambitious in terms of scope, scale, and complexity. As we progress in our study and knowledge of restoration science, better information, techniques, and technologies are emerging that form a scientific basis for the specific ways to approach restoration of various ecosystems and habitats. Much of the information comes directly from restoration projects used as opportunities for research and monitoring data.

Although project monitoring is extremely important, in order to document achievement of goals and to modify projects in response to unforeseen circumstances, monitoring has not been as frequent or thorough as it should be. For instance it is estimated that since 1990 about $1 billion per year has been spent on stream and river restoration projects in the United States; however, the effects of the efforts are not well known, as only about 10% of the projects were assessed or monitored (Bernhardt et al. 2005). Monitoring data are critical for improving restoration projects, and funding for monitoring should be considered an essential part of all project proposals. Restoration and other management practices are becoming more commonly and extensively used to improve habitats; therefore, it is important to use the best available techniques and most current information, so that lessons learned can be incorporated into new project plans and used in adaptive management of ongoing projects.

Special Theme Papers

The papers contained in this special theme issue cover a range of subjects. Several address large-scale strategies, such as how to prioritize restoration projects within a watershed, and uses of advanced technology (such as geographic information systems [GIS] and hydrodynamic modeling) to provide guidance for restoration practitioners in project planning and implementation. Because it can integrate and overlay multiple data sets for simultaneous viewing of many variables, GIS is a valuable tool that is frequently used to assess conditions and evaluate proposed project sites. Databases for fast information retrieval, and software for creating predictive models are also being used in many projects. These papers include data and information from all North American coasts, as well as some commentaries and reflections on the history of past restoration efforts, and some philosophical considerations.

Restoration Notes

Teal and Peterson, in their Restoration Note, address the central question of the special theme and briefly recount some examples of successful large-scale restoration projects in coastal wetlands. Despite some bleak statistics, they provide some evidence for optimism about wetland habitat restoration in the United States. Teal and Peterson conclude that, though much remains to be done, restoration efforts have indeed made a difference in environmental awareness and public policy, and also environmental education.

The Restoration Note by Erwin and others was not among the initial group of papers contributed for this special theme but is included because it deals with an estuarine habitat (in Chesapeake Bay, Maryland) and is directly related to the theme. The authors provide information about several bird populations establishing on a restored island, and the positive effects of predator removal. It is an example of effective use of scientific information to successfully restore some bird populations in the bay, and using continuing monitoring to inform management actions.

Papers

Seagrasses—One of the many coastal ecosystems adversely affected by human activities is seagrass meadows. In a global assessment, Waycott and others (2009) found that seagrass areas have declined 29% since 1879 and that the rate of loss has increased to 7% per year since 1990. Some estuaries in the northern Gulf of Mexico, United States (e.g., Mississippi Sound), have lost over 70% of total seagrass coverage (Handley et al. 2007). Seagrass restoration has been in progress in the United States for about 70 years. In "Addy Revisited," Fonseca compares current seagrass restoration practices with earlier restoration efforts in the 1940s by C.E. Addy, a biologist with the U.S. Fish & Wildlife Service. Discussing sources for plants, site locations, planting techniques, equipment, and bioturbation, he also raises some concerns regarding effective use of the seagrass restoration literature, especially in the site selection process.

Even though seagrass has declined in many estuaries in the United States, Greening and colleagues report the Tampa Bay Estuary Program's success in restoring seagrass in some areas of Tampa Bay, Florida, implementing strategies at the watershed, regional, and local level. Using historical data, they established goals for seagrass recovery, via reduced nutrient loading in the bay, to increase water clarity and light penetration. Creative management and experiments are helping them to refine techniques, technology, and approaches for measuring these variables and are expanding their understanding of other stressors that are inhibiting seagrass recovery in specific parts of the bay.

Fish Habitat—The number of imperiled freshwater fish and invertebrate species in the conterminous United States is mostly a result of human activities such as urbanization and agriculture in upland areas and dam construction. Efforts to rehabilitate fish habitat have reached unprecedented levels in recent decades as the vital connections between upland land use and the health of waterways have become better understood and appreciated by more people. However, funding for such projects is limited relative to the work that needs to be done. Thus, perhaps one of the most universal problems in ecological restoration is how to prioritize restoration projects. Three papers in this issue deal with different aspects of fish habitat restoration projects.

Thom and colleagues present a two-tiered prioritization framework for salmonid habitat restoration projects in the Lower Columbia River estuary system. In the first tier, various controlling factors, stressors, and other data are used to calculate scores for individual sites and larger management areas, which can be viewed as a GIS map to provide valuable insights. In Tier II, specific projects are evaluated and ranked using best professional judgment and a set of metrics. The authors include a hypothetical example to show how the framework can maximize the potential for project success by identifying the best project sites and selecting the most appropriate kinds of projects for those sites.

Another important question in restoration science revolves around determining whether a multitude of small projects eventually produce a significant restoration "signal" in the broader ecosystem within which they reside. Diefenderfer and others describe an approach they have successfully implemented to assess the cumulative effects of multiple salmonid habitat restoration projects on the surrounding ecosystem (the Lower Columbia River Estuary). They apply a tool from ecotoxicology termed *levels of evidence* to infer cause-and-effect relationships from restoration projects on a broad scale. The authors discuss the various components of the framework they established for measuring cumulative restoration effects and the theoretical basis for the steps involved. In a departure from most site-focused assessments, they view the estuary as the experimental unit and use scientific inference to provide a basis for showing cumulative effects of the restoration projects. The framework presented is well worth considering for application in other large aquatic systems where multiple restoration projects for a specific habitat or species are being undertaken.

One large-scale effort aimed specifically at improving fish and shellfish habitat in the United States is the National Fish Habitat Action Plan (NFHAP). An essential part of this endeavor was the development of a database that indicates the level of anthropogenic disturbance or stressors. In their paper, Esselman and others detail the selection and use of different variables to assess and score more than two million stream reaches in the conterminous United States. They also show how data can be portrayed graphically using GIS software to indicate cumulative impacts on different hierarchical scales, from stream reach to ecoregion. Their paper is the culmination of several years of work involving input from scientists and stakeholders across the country, and their data and scores constitute the NFHAP inland assessment. They present their statistical procedures, share examples of maps generated by the database, and discuss a methodology for using the disturbance scores to help determine the most appropriate management strategy. The data and GIS maps from the NFHAP inland assessment compiled by Esselman and colleagues will be very useful tools, not only for NFHAP partnerships, but for many others involved in freshwater fish habitat management and restoration activities throughout the United States.

Biodiversity—Restoration projects aimed at maintaining biodiversity are often challenges, especially in some environments beset by multiple devastating natural events and anthropogenic disturbances. Zedler recounts the interesting history of restoration efforts in the Tijuana Estuary, California, and the many existing and future challenges. She offers her insights, gained from years of experience in marsh restoration, and suggests that, given the situation, acceptance of the resulting novel environment is perhaps a suitable alternative. The author then poses several questions about marsh sustainability and restoration design and provides suggestions about experimentation to answer the queries within an adaptive restoration framework. Flexibility and willingness to adapt approaches are two key lessons to be learned from restoration in Tijuana estuary.

Hydrology—Floodplains are important features of rivers and, among other functions, serve as buffer zones between agricultural/urban areas and rivers, absorbing and retaining nutrients during flooding events and forming mosaics of various habitat types. Connectivity between rivers and floodplains is essential for maintaining biodiversity and for energy flow between the two systems. Over the last 200 years, however, channelization of rivers in many places in the United States, along with the addition of drainage control structures for agricultural expansion, has resulted in the disruption of normal water flow and reduction of important fish and wildlife habitat in floodplains. In the last two decades, many restoration projects have been implemented with the goal of removing dikes, dams, levees, and other structures in floodplains, and restoring normal flow and connectivity to the rivers they border.

It is abundantly clear that restoring natural hydrology and hydrodynamics is the key element in initiating the processes that form and maintain habitats; however, hydrological analysis is often missing in the restoration planning process. In their article, Breithaupt and Khangaonkar present a hydrodynamic model to describe water flow over a flood plain on the Grays River, a tributary of the Columbia River estuary. Using data from an extreme flood event, they evaluate the effects of a restoration project, designed to reconnect the flood plain to the river, on the direction, drainage, and water heights across the flood plain during the flood event. Other engineers and restoration practitioners may find the methodology in this paper very useful for modeling potential project effects in floodplains during the planning phase of restoration projects.

Using the Puget Sound circulation and transport model they developed, Khangaonkar and Yang explore how a lack of quantitative information about hydrologic processes by project planners can result in delays in implementation and how conventional engineering tools may be limited and cause unintended consequences. They present examples of several restoration projects in Puget Sound to improve nearshore salmon habitat and the use of their model, which helped planners avoid costly mistakes and provided valuable information for refining restoration actions.

These papers illustrate some of the recent progress in restoration science, and also some topics of ongoing debates about approaches for restoration of specific habitat types. Several of the projects discussed, especially those dealing with fish, demonstrate how cultural icons can inform our practices (for example, restoring salmon habitat) and reflect our best human aspirations to interact with, and be part of, our environment.

The Future

Human beings will continue to alter their environment as the human population grows and more resources are needed to provide for more people. However, there is hope that people will eventually come to understand, appreciate, and be committed to living more sustainably and in harmony with nature, and not apart from it as consumer and destroyer of it. This includes a new environmental ethic and ecological restoration, through which we heal and transform the environment, and we, in turn, as William Jordan says (2003, 197), are also transformed by our interactions with the environment. Jordan foresees restoration becoming "the dominant paradigm," which will link human cultures and the rest of nature, and become established as part of the rituals and essential activities in our lives.

Indeed, environmental restoration is emerging as part of the "restoration economy," which is restoring and integrating natural and built environments for the benefit of both, and is now more than a trillion dollar growth sector of the economy (Cunningham 2002). There are currently many thousands of citizens and organizations in the United States and around the world involved in restoration and conservation projects, both terrestrial and aquatic. The success of these and future restoration efforts will be greatly enhanced by constantly improving technologies and the expanding science of restoration ecology. Citizens' participation in these efforts will continue to increase people's direct interaction with their environment, hopefully engendering and shaping the new *Intichiuma.*

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