The Science and Values of Restoration Ecology

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It has been 22 years since William Jordan III and the University of Wisconsin Arboretum published the first issue of Restoration and Management Notes, 16 years since the founding of the Society for Ecological Restoration (SER), and 10 years since SER published the first issue of its flagship journal, Restoration Ecology. In this short time, restoration ecology has become a leader in North American conservation efforts. Believing it is important that the field has a strong scientific foundation (Bradshaw 1993), restoration ecologists have emphasized concepts such as 'ecosystem health' and 'ecosystem integrity' when articulating restoration goals and frequently have invoked ecological principles when describing and justifying their objectives (SER 2002). Although ecology plays a central and essential role in the implementation of restoration projects, we believe that defining restoration goals and objectives is fundamentally a value-based, not scientific, activity.

Since its inception, SER has taken the lead in developing and articulating paradigms of restoration. SER's most recent major publication, The SER Primer of Ecological Restoration (SER 2002), is developed around the notion that communities and ecosystems are ecological entities. In the Primer, the goal of restoration is stated to be "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed." The Primer describes a recovered ecosystem as one that "contains sufficient biotic and abiotic resources to continue its development without further assistance" and for which "potential threats to the health and integrity of the restored ecosystem have been eliminated." An ecosystem is also considered restored when it "apparently functions normally for its ecological stage of development, and signs of dysfunction are absent." The idea that communities and ecosystems possess traits such as health and integrity, that they exhibit an organic development, that their "health" can be injured or harmed and then can be restored through informed efforts of ecologists is reminiscent of earlier ecological claims of communities and ecosystems as integrated entities (Clements & Shelford 1939).

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Attributes such as "health" and "integrity" can be meaningfully applied to entities that have been directly shaped by evolution, such as individual organisms. Organisms normally have clearly defined boundaries and a myriad of homeostatic mechanisms that maintain those boundaries while the organism develops, matures, and reproduces. However, communities and ecosystems are not shaped as entities by evolution.

Today, communities are no longer believed to be tightly organized systems (Slobodkin 2003). They are believed to lack coherence (Gould 2002) and clear boundaries (Stiling 1999). A community or ecosystem does not possess distinct boundaries nor does it have mechanisms that have evolved to regulate particular processes. Communities do not exhibit any kind of evolutionary imperative, such as reproduction, as do individual organisms. The terms "community" and "ecosystem" are useful in a practical sense for referring to species and processes occurring in a particular locale (O'Neill 2001), but this does not mean that there actually exists some integrated entity out there called an ecosystem that grows, lives, reproduces and dies, or can be injured or healed.

If ecological communities and ecosystems lack any intrinsic evolutionary or ecological purpose, one cannot validly invoke any ecological (or evolutionary) rationale to establish particular restoration goals. As noted by Diamond, "this goal [of restoration ecology] is not itself a self-evident mandate. It is a choice based on values, and it is only one of many possible choices" (Diamond 1987). Restorationists have often tried to justify their goals by presenting them as fulfillling various ecological imperatives, e.g., restoring ecosystem health and restoring indigenous environments. However, characterizing communities and ecosystems as "healthy" or "damaged" is a value-based, not scientific, assessment (Lackey 2001).

Architecture uses mathematics, physics, and engineering in its efforts to achieve a particular result of aesthetic and social value. In an analogous fashion, restorationists must use ecology, and often geology, soil science, and more to achieve results of social value. Often, their results are also of great beauty as well. Perhaps, "ecological architecture" might be a more apt characterization of the work of ecological restoration, because the term acknowledges the central roles played by both values and science.

Ultimately, it is important that restorationists do their best to clearly distinguish between their science and their values in their discussions with the public and policy

makers as well as amongst themselves (Kapustka & Landis 1998; Lancaster 2000). Restorationists and their supporters must make their cases in the same socio- politico arena as any other advocacy group and justify the merits of their preferences to the various stakeholders in the same way, using social, cultural, economic, health, and ethical arguments. Whether those preferences are for a historical environment, a species-rich environment, a particular set of species, or some other type of landscape, restorationists cannot logically or ethically invoke ecology or evolution as a justification for these preferences. Ecology and evolution, and other scientific disciplines, appropriately come into play during the actual implementation of the stated social goals. Consider the following proposed definition of ecological restoration:

> "Ecological Restoration is the process of restoring one or more valued processes or attributes of a landscape."

This definition does not invoke questionable ecological concepts such as ecosystem health and ecosystem development, and it acknowledges the important role values play in the field. It also permits restorationists to define a wide range of restoration objectives, such as restoring high levels of diversity and/or productivity, restoring a habitat so that it is again suitable for one or more target species, restoring desired aesthetic qualities or recreational opportunities of an environment as well as restoring a historic ecosystem. Although flexible, this definition does not open the door for any arbitrarily chosen landscape transformation to be considered ecological restoration. For example, converting a grassland into a housing subdivision or a parking lot would not fall under this definition, because the valued qualities of the subdivision and parking lot would represent new, not restored, attributes.

By arguing that the field "must also be a science", Bradshaw (1993) was not denying the artistic element of restoration, and the important role played by social values has been emphasized by other restoration ecologists as well (Higgs 1994; Jackson et al. 1995). However, 10 years later, one wonders whether Bradshaw's call for a scientific foundation has been followed a bit too enthusiastically. By continuing to try to frame its goals and objectives in a scientific context, the field, paradoxically, may actually be undermining its credibility. Whatever the desirable features of a proposed restored environment are deemed to be, this decision lies in the social, not scientific, realm (Lackey 2001). The field of ecology becomes important during the implementation stage of a restoration, when ecological knowledge and understanding are necessary to successfully manipulate and manage an ecological system to achieve desired goals.

Other scientists and philosophers have voiced similar concerns regarding the paradigms and language used by restoration ecologists (e.g., Suter 1993; Pickett & Parker 1994; Callicott 1995; Sagoff 1995; Lele & Niggaard 1996; Gould 1998; Kapustka & Landis 1998; Lancaster 2000; Lackey 2001), and there has been considerable self-reflection from within the field on these issues as well (Higgs 1994; Aronson et al. 1995; Ehrenfeld 2000; Hobbs & Harris 2001; Swart et al. 2001). We applaud recent comments from Dr. Edith Allen (2003), Editor-in-Chief of *Restoration Ecology*, who announced that the journal will be broadening its focus to include more of the social dimension of restoration and emphasized that "restoration is not only about the science of ecology but it also includes societal decisions on appropriate end points for restoration, economics of restoration and the valuation of nature, policy and planning, education and volunteerism, and other social and philosophical issues."

That restoration ecologists must involve themselves with values, public policy, and science is, no doubt, one of the reasons so many students are attracted to the field as a career option. We believe that if the field is willing to accept, and even embrace, the fact that the definition of its goals is fundamentally a value-based social enterprise, and focus its scientific efforts to the implementation of restoration objectives, it will considerably strengthen its position, now and for many years to come.

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ecological restoration, because the term acknowledges. the central roles played by both values and science. Ultimately, it is important that restorationists do their. best to clearly distinguish between their science and their. values in their discussions with the public and policy. 1. Department of Biology, Macalester College, Saint Paul, MN 55105, U.s.a. 2.Â is not only about the science of ecology but it also includes. societal decisions on appropriate end points for restor-. ation, economics of restoration and the valuation of nat-. ure, policy and planning, education and volunteerism, and. other social and philosophical issues.â€™â€™ That restoration ecologists must involve themselves with. values, public policy, and science is, no doubt, one of the. Despite centuries of restoration projects, restoration ecology was not formally recognized as its own scientific discipline until the 1990s (Allen et al., 1997). Until then, grass-roots restoration projects were common throughout the world in the form of invasive species removal (Howald et al., 2007), native species introductions (Towns and Ferreira, 2001), and native plant revegetation (D'Antonio et al., 1992).Â One thing that distinguishes restoration ecology from most other hard sciences is its explicit inclusion of societal values in its goals. People set restoration goals, meaning goals are often selected according to subjective views of what society needs or wants from a particular ecosystem. Restoration ecology specifically refers to the scientific study that has evolved as recently as the 1980s. Land managers, laypeople, and stewards have been practicing restoration for many hundreds, if not thousands of years (Anderson 2005), yet the scientific field of "restoration ecology" was first identified and coined in the late 1980s by John Aber and William Jordan. The study of restoration ecology has only become a robust and independent scientific discipline over the last two decades (Young et al. 2005). The Society for Ecological Restoration defines ecological restoration as an â€œintentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainabilityâ€ (SER 2004). View Restoration Ecology Research Papers on Academia.edu for free.Â Globally, annual expenditure on ecological restoration of degraded areas for habitat improvement and biodiversity conservation is approximately $18bn. Seed farming of native plant species is crucial to meet restoration goals, but may be more.Â Seed farming of native plant species is crucial to meet restoration goals, but may be stymied by the disconnection of academic research in seed science and the lack of effective policies that regulate native seed production/supply.Â The value of N storage represents one of the highest monetary values presented for an ecosystem service provided by seagrasses, and show that Swedish eelgrass meadows are particularly important for mitigating eutrophication.