Chapter 14

Merging Economics and Ecology in Ecological Restoration

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The late Kenneth Boulding contended, "Mathematics brought rigor to economics. Unfortunately it also brought mortis." Although it would be fair to say that economics is not the only discipline suffering from this type of rigor mortis, the public's disappointment with mainstream economic theory has been more pronounced because of mainstream economic failures in solving real-life problems (Blag 1998; Wilson 1998; Gowdy 2000). Even the 1996 Nobel Laureate of Economics, William Vickrey, dismissed his prize-winning 1961 paper as "one of my digressions into abstract economics. . . . At best, it's of minor significance in terms of human welfare" (Cassidy 1996, 50). Is the future of the dismal science that dismal? We argue not, precisely because of the earlier self-reflections prompted by the chorus of critics. "Those scholars working on the frontiers of economics have firmly put behind them the inward-looking reductionism" and, as a result, economics is enjoying a "remarkable creative renaissance" refocusing its efforts to help solve real-life problems (Coyle 2007).

The emergence of ecological economics in the late 1980s is a good example of this renaissance. Its clear focus is to help answer the questions that really matter, such as, How can we humans, as a species, have a long and happy life? Currently, many problems that humans encounter, and which we try to repair through efforts such as ecological restoration, have been attributed to past management actions that have dramatically altered ecosystems. For example, ponderosa pine ecosystems were rapidly changed by livestock grazing, high-grade logging, fire suppression, and some forms of recreation during the last 120 years in the American Southwest (ERI 2008). Many unintended ecological consequences of these altered ecosystems have been well documented (e.g., Covington and Moore 1994) and, as in numerous other degraded landscapes, ecological restoration has been proposed to help return these ecosystems to a healthier, more natural trajectory. However, the public and even many conservationists view ecological restoration as "an expensive self-indulgence for the upper class" (Kirby 1994, 240) or "a diversion, a delusion and . . . a waste of money" (Aronson et al. 2006a). If advocates of ecological restoration are to convince their critics and gain broader support, they need to better incorporate socioeconomic and political perspectives as well as greater scientific foundations in restoration projects (Jordan 2003; Choi 2007; Temperton 2007). In other words, ecological economics has much to contribute to, and learn from, restoration ecology and ecological restoration.

This chapter introduces the lessons learned in the field of ecological economics to advocates of restoration in order to bring greater effectiveness to our collective actions. In this chapter, we critically review various concepts from neoclassical and ecological economics, explain why they would prove to be useful in understanding the socioeconomic and political contexts of ecological restoration, and suggest the key areas of social research interests for postnormal ecological restoration studies. To illustrate the interface between highlighted economic concepts and on-the-ground restoration efforts, we provide examples from forest restoration in the western United States and detail why these connections are applicable to broad ranges of restorative actions.

Is Ecological Restoration a Rational Choice?

Ecological restoration is our effort to mediate past mistakes and reestablish the ecological integrity of an ecosystem while protecting human interests. According to the Society for Ecological Restoration, "Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER 2004, 3). One would be hard pressed to argue against the "recovery of damaged ecosystems," in principle and, indeed, both ecological restoration and restoration ecology experienced astonishing growth in the past decades (Choi 2004, 2007; Davis and Slobodkin 2004). Although significant research efforts help settle the public concerns for biological and ecological consequences of most forms of restoration, the majority of restoration-related management action to date has been either mitigation required by law (Holl, Crone, and Shultz 2003) or as a response to protect social and economic interests threatened by degraded ecosystem functions and processes. For example, most forest restoration efforts in the western United States have primarily been fuels reduction treatments within or near the wildland–urban interface. Likewise, large restoration projects in the Florida Everglades, Denmark's Skern River, and the San Francisco Bay delta were all catalyzed only when degradation caused by development began severely impacting social and economic interests, typically in the form of reduced water quantity or quality (Weisskoff 2000; Mitsch and Jorgensen 2004). Currently, capital and property, along with the associated ecosystem services necessary for the inflation of their economic value, need to be at risk in order to galvanize the social, political, and economic will to undertake large restoration projects. However, anticipating future risks combined with the economic and ecological gains that come from proactive management certainly justify ecological restoration of degraded areas prior to their impingement upon society's lifestyle. We believe that a basic understanding of economic efficiency and its limits can help us answer the question of whether or not ecological restoration is a rational choice, and can provide an exploration of a new role for economics in ecological restoration—one that does not throw the baby out with the bathwater.

Neoclassical Economics and Ecological Restoration

The basic premises of neoclassical economics include methodological individualism, rationality, and marginalism (Venkatachalam 2007). In other words, individuals acting as economic agents are only interested in their own utility and are able to make rational choices that provide maximum utility to them by comparing marginal utility with marginal cost. Although these premises have proven useful for gaining sharp analytical focus in economic studies, ecological economists have been questioning the limits of their usefulness. These perspectives, which we will discuss, can be summarized as follows: (1) methodological individualism, (2) neoclassical rationality, (3) marginalism, and (4) reactivity and proactivity.

Methodological Individualism

Economic theory posits that the optimal choices we make in a perfect market as individual consumers result in the best outcome for society—the most economically efficient outcome. The market will guide us like "the invisible hand" to the allocation where marginal cost meets marginal benefit, and where collective net benefit is maximized. Mark Sagoff (1988) has effectively argued that this is a flawed assumption because individuals have different and conflicting "preference maps" as citizens and as consumers. In other words, even if we accept that the neoclassical economics perspective of a consumer having a complete and continuously ordered sequence of wants and needs is correct, we cannot deny that the same individual, when acting as a citizen in a community, may have an entirely different set of ordering. These often incompatible preferences cannot be combined in any logical order. An individual is a parent, citizen, and consumer, and employs different sets of preference maps for different purposes. The preference ordering that we use when we shop is not the same one we express when we vote. Like Sagoff, we dislike having smoke from prescribed fires and long-lasting slash piles on our favorite hiking trails. Nonetheless, we fully support the public policy that would encourage more smoke and slash piles for the "recovery of damaged ecosystems." Basing our ecological restoration decisions on economic methods, such as cost-benefit analysis (a sum of our wants and desires as individuals), may not result in what we think we should do collectively.

Neoclassical Rationality

Rationality is another basic premise in neoclassic economics. In other words, individuals and institutions always make rational choices when deciding about economic matters. Ecological economics see it differently. For example, Gary Snider and his colleagues (2006) showed that the cost of fire suppression itself exceeds the cost of proactive thinning treatments in the American Southwest. Assuming one-third of the forests in Arizona and New Mexico require thinning treatments, these researchers estimated that treating just 5 percent of the required acreage (163,000 acres) annually would reduce fire suppression costs by $600 million over time. Thus they concluded that the current policy of continuing fire suppression with limited treatments is both ecologically and economically irrational.

Why are we behaving so irrationally? We can attribute some of the irrationality of public policy to institutional barriers and politics of interests that prevent us from acting rationally as a group. Additionally, behavioral economists have long argued that the unbounded rationality assumption is at odds with empirically observed human behavior (Gowdy 2004). In laboratory and field experiments, individuals demonstrate "targeting" or "satisficing" behaviors (choosing an option that is good enough) instead of "maximizing" behaviors (choosing the option that would give maximum satisfaction). There are many possible reasons for this bounded rationality. Mainstream economists tend to attribute the observed behavioral anomalies to cost-effective strategies for minimizing the costs of information gathering, transaction, and commitment, resulting from uncertainty, irreversibility, and limited learning opportunities. However, many behavioral economists argue that there are fundamental biases in the human psyche which place bounds on rationality. For example, individuals place greater value on preventing the loss of what they already have than on potential gain (endowment effects). Humans also tend to prefer the status quo over change (status quo bias or inertia in behavior) and respond to a kindness or meanness of others with matching acts (reciprocal behaviors) (Venkatachalam 2008). The concept of bounded rationality helps us understand irrationality (and resistance toward ecological restoration), and suggests ways to counteract our collective inertia.

Marginalism

Marginalism is another premise of neoclassical economic analysis. In many situations in life, decisions are not about having all or nothing, but about making small incremental changes. Comparing marginal benefits and marginal costs help us evaluate the trade-offs of having one more widget. The intensity of wants and needs for each good declines as we acquire more units of the good, which is the economic principle of diminishing marginal utility. In this framework, the economic value of each good is determined by its utility and abundance/scarcity. Thus the classic paradox of economic value was born: water versus diamonds. This means that until a valuable ecosystem service hits a critical threshold, its economic value is determined by its scarcity rather than its innate importance in sustaining our lives. However, because substitutability is assumed, scarcity is only evaluated in relative terms. If we can ignore the limits of economic activities imposed by ecosystems (i.e., absolute scarcity), evaluating marginal benefits and marginal costs based on relative scarcity would be perfectly valid in deriving important decisions in our personal or collective lives. Anyone with an anthropocentric view could agree nothing should be wasted and everything should be used to maximize our utility. Nobel Laureate economist, Robert Solow, once stated that "If it is very easy to substitute other factors for natural resources, then there is in principle no 'problem.' The world can, in effect, get along without natural resources, so exhaustion is just an event, not a catastrophe." (1974, 11) Ecological economists have been arguing that the concept of scale and limits should be fundamental in evaluating the benefits and costs of our economic activities. Absolute limits of our economic activities need to be recognized if humans are going to have a long and happy life, rather than a short and eventful one. Georgescu-Roegen put it succinctly in 1975 when he wrote "Every time we produce a Cadillac, we do it at the cost of decreasing the number of human lives in the future" (Georgescu-Roegen 1993). In this sense, the economic principle that "rational people think at the margin" (Mankiw 2001) is only valid when the context and scale of the decision are clearly predefined. Unfortunately, the context and scale of decisions have the most clarity when one's livelihood is imminently threatened (e.g., wildfire is approaching, water is too polluted for use, etc.); they are often less clearly defined in the postnormal world we inhabit.

Reactivity and Proactivity

In a capitalistic society, land management often boils down to the collective will of self-interested, rational individuals operating at the margin with the purpose of maximizing their own utility. This often translates into the necessary *reactive* action when we finally have all the information after the fact. Putting out a wildfire becomes clearly rational, both individually and collectively, once the fire threatens life and property. The rationality of a more *proactive* approach to reduce fuel loading in the neighboring forests is not always so clear to individuals with imperfect information. Investigating the role and value of improved information has been an active research area in agricultural and forest economics. Amacher et al. (2005) estimated that forest owners who underestimate both fire risk and efficacy of fuel treatment can double their expected rent by having more accurate information. Indeed, lack of information for individual decision makers can lead to substantial private and social losses from forest fires (Amacher et al. 2006). Likewise, game theory applied in economics can provide an analytical framework to predict collective outcomes when interactions among individual decisions determine the outcomes. Chapter 17 in this volume presents an analytical model for applying game theory in ecological restoration projects.

Certainly it is an important policy goal to gather reliable information, improve access, and provide incentives for individuals to incorporate better information and cooperate with others. However, we also need to recognize that a complete set of information for any given decision is often an unattainable goal, especially when we are faced with a high degree of uncertainty and irreversibility in decisions with far-reaching and long-lasting consequences. A proactive approach is useful when trying to anticipate the inevitability and fix the root problems that cause and exacerbate the impacts to social and economic interests stemming from degraded ecosystems. This notion of ecological restoration requires a shared vision among community members that can prompt action without full and complete information and strategies to deal with an inherently unpredictable future. Unfortunately, the fundamental differences between risk, uncertainty, and inherent ignorance (radical uncertainty) have not been well understood in economics and other decision sciences (Ludwig 2001).

To the question, Is ecological restoration a rational choice? we can only offer a typical answer from economists: It depends. Supporting an ecological restoration project may or may not be a rational choice for individual consumers, depending on perceived marginal benefits and costs to each person. However, one could wonder if the question itself is rational. Borrowing from Daly's nautical plimsoll line analogy (Daly and Farley 2004), if your ship's weight is such that your ship is sinking below the plimsoll line, the collectively rational question to ask is, How can we rearrange and get rid of some of the cargo now? not, Will marginal benefits from one more load exceed marginal costs? Ecological economics is a paradigm shift from neoclassical economics because its first action is to ask, What are the rational and prudent questions to ask when in pursuit of sustainability? For example, if ecosystem conditions and processes have been damaged to a critical point, the rational choice beyond marginalism is to promote the "recovery of damaged ecosystems." The Millennium Ecosystem Assessment (2005) concluded that approximately 60 percent of the world's ecosystem services are in decline and are being used unsustainably, which, in turn, causes significant harm to human well-being. The imminent problem is known. The question to ask is, How we can effectively go about solving it?

Ecological Economics for Ecological Restoration

The ecological path that advocates of restoration nearly everywhere are trying to correct was set by past management and development paradigms. For instance, in the United States ideas and practices were driven by the utilitarian philosophy of the Progressive Era. To the Progressive Era conservationists, like Gifford Pinchot, Theodore Roosevelt, and Stephan Mather, resources are for use. Thus their primary concern was to set policies and build public institutions to reduce waste and inefficiency in the use of natural resources (Hays 1959; Cortner and Moote 1999). Under the "gospel of efficiency," the scientific management of forest fires translated into the effective protection of resources against fire, later characterized as the policy to wage war on the forces of nature (Nelson 2000). Neoclassical economics, along with other reductionist disciplines, provided the theoretical and political base for the scientific management of efficiency, where management decisions are based on "objective science" that can transparently evaluate trade-offs among multiple uses of ecosystems. But, as Einstein duly noted, "We cannot solve the problems we have created with the same thinking that created them." Our current problem of degraded ecosystems cannot be solved by simply adding more ecosystem state variables to the same old framework of sustained yields and economic efficiency.

Indeed, Norgaard (2004) among others argued that modern science, compartmentalized within various epistemic communities, is "neither fit nor organized to address the whole and inform collective action." In an earlier paper, Norgaard (1989) illustrated that methodological diversity and cultural adaptation need to be consciously maintained for ecological economics to effectively work within a range of answers. Others went a step further and argued that the mode of scientific inquiry itself has to be different if we are to offer effective solutions to the most urgent problems in the face of inherent uncertainties and the value-laden nature of science and policy making (Funtowicz and Ravetz 1993, 1994). "Post-normal science," a phrase coined by

Funtowicz and Ravetz, is so termed because its scope goes well beyond the puzzle-solving nature of normal disciplinary science (Müller 2003). Postnormal science implies a qualitative change in how we gain knowledge and formulate public policies. Instead of the expert professionals paradigm that has held sway since the Progressive Era, postnormal science holds that engaging stakeholders in the process is critical to making better, more socially acceptable decisions, given the complexity and uncertainty of issues (Frame and Brown 2008).

Ecological economics is the science and management of sustainability (Costanza 1989), where knowledge gathering should be directly linked to informing the course of necessary actions in a normative manner. Perhaps, the most distinguished feature of ecological economics is its transdisciplinary exploration of human–economy–environment interaction (Venkatachalam 2007). As in the field of ecological economics, the focus of ecological restoration is on increasing the chance of restoration success rather than pursuing precision in scientific and technical details. For instance, William Jordan III, founding editor of the journal *Ecological Restoration* and a founding member of the Society for Ecological Restoration, argued that restoration of nature needs to be explored as an experience and a performing art as well as a technology. Many restoration ecologists argue that restoring an ecosystem is a value-laden statement and urge researchers and practitioners to explicitly recognize the importance of social, economic, cultural, and political factors in defining the goals and scope of projects (Choi 2004, 2007; Hobbs et al. 2004). In recent years, restoration ecologists have called for greater recognition of the transdisciplinary nature of restoration and have acknowledged that collaboration among all stakeholders is the current challenge for both ecological restoration and restoration ecology (Temperton 2007). In this section, we establish the need to link ecological restoration to economic decisions for regional economies by explaining why and how ecological restoration makes perfect economic sense if we look beyond the basic premises of neoclassical economics. Some of the developments in ecological economics can help us improve our institutional and organizational settings to encourage people to express their preferences as citizens when collective choices and actions are necessary. We also suggest ways to reduce the chance of decision failures due to bounded rationality when dealing with a high degree of uncertainty or inherent ignorance (i.e., we do not know what we do not know).

Why Ecological Restoration Makes Economic Sense: Investing in Natural Capital and Resilience

Although the environment has been abstracted out of the standard view of economics, the concept of sustainability has been recognized and incorporated into the definitions and distinctions between capital and income. Capital is essentially a stock that generates flows (income) of goods and/or services. As long as one does not deplete the level of stock and survives on the flows yielded, wealth can be sustained. Ecological economists apply this concept to operationalize the pursuit of sustainability and to clarify what needs to be sustained (Daly and Farley 2004; Farley and Gaddis 2007).

Total capital (our total assets) is divided into natural capital and humanmade capital. Natural capital is defined as ecosystem services that are "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily 1997). In this sense, there are many functions *of* natural capital that support and enrich our lives in addition to providing various functions *for* humans (De Groot et al. 2002; Ekins et al. 2003). Natural capital has two dimensions: nonrenewable and renewable. Although humanmade capital (e.g., technology or machinery) may reduce some of our needs for natural capital, ecological economists contend that natural and humanmade capitals are ultimately complementary to each other. Ecological economists termed this view as "strong sustainability," and called the conventional assumption of substitutability between natural and humanmade capitals "weak sustainability" (Daly and Farley 2004). To wit, a house cannot be built without land and lumber, no matter how many carpenters and hammers we employ.

These concepts of natural capital and strong sustainability clarify where we should seek solutions for sustainability. If humans as a species are going to have a long and happy life, the level of natural capital must be maintained over time. By definition, the stock of nonrenewable natural capital is being depleted with our economic activities. The only way to maintain or even improve the level of natural capital is by developing renewable substitutes for nonrenewable natural capital while restoring and increasing the stock of renewable natural capital. When faced with this reality, investing money into the "recovery of damaged ecosystems" makes perfect economic sense.

Natural capital is a major extension of the concept of "land" from the classical economic analysis where three types of stocks (land, labor, and humanmade capital) were identified (Ekins, Folke, and De Groot 2003). Adam Smith viewed the flows of values derived from these three types of stocks (rent, profit, and wages) as the original sources of exchange value (Farber, Costanza, and Wilson 2002). With limited substitutability among the different types of stocks, the value of a final product is primarily determined by the most scarce production input. In Adam Smith's time (the eighteenth century), labor was the scarce factor, and he suggested a labor theory of exchange value. Currently, it is the stock of natural capital that is being depleted and, as a result, the availability of natural capital is increasingly the limiting factor in production that will drive up the value of final products in the future. Restoring natural capital would also make perfect economic sense in the eyes of the father of modern economics. This point was elaborated further in detail by Aronson et al. (2006b) and Farley and Daly (2006) in their dialogues advocating ecological restoration as an economic problem (i.e., restoration of natural capital is restoring the limiting factor of production).

Another way that ecological restoration makes economic sense is as insurance. Despite the fact that rationality based on predictability is a basic tenet of neoclassical economics, most of us understand the future is inherently unpredictable. Some of the largest expenditures for a household in the United States are payments for various insurance premiums to reduce the chance of financial downfall due to future risk and uncertainty. Inherent unpredictability of events has been recognized even in financial trading where predicting uncertain futures is the core of the field. Taleb argued in his 2007 bestseller, *The Black Swan: The Impacts of the Highly Improbable* (Taleb 2007), that most of human history has been shaped by rare events having far-reaching consequences and retrospective predictability (see also chap. 17, this volume). Likewise, ecologists have long recognized that ecosystem changes are rather episodic and brought on by sudden release and reorganization after slow accumulation of slow-moving factors. Since the 1970s, the dynamic nature and multiple stable states of ecosystems have been recognized to be the result of interactions between slow-moving and fast-moving processes and between large-scale and localized processes (e.g., Holling 1973). Slow-moving factors are impossible to predict and control. Management of ecosystems to achieve efficiency (e.g., fire suppression) tends to focus on control of fast-moving factors to achieve constancy and predictability, which often ends up with counterproductive results (e.g., lost resilience) (Holling and Gunderson 2002). Unnatural future events spurred by past management, which may permanently alter the stable state of that ecosystem, are unavoidable consequences of increased system rigidity and lost resilience. Ecological restoration that recovers damaged ecosystem functions and processes should then increase resilience, allowing small cycles of releases and reorganizations of fast-moving factors and promoting ecosystems' ability to persist and adapt. Just as buying an insurance policy, ecological restoration is a sound economic decision.

These concepts of ecological economics help us translate ecological problems into terms directly relevant to human economies and promote urgently needed actions. Comprehensive ecological restoration of large ecosystems for its own sake may be appealing ethically to restoration ecologists but has little chance for implementation. We argue that, to be effective in promoting collective actions, we need to stop seeing the world through "humans versus nature" lenses (Woodworth 2006), and find ways to promote social-economic development while restoring ecosystem health. Human systems cannot exist without functioning ecosystems, and the current state of ecosystems requires our conscious efforts for restoration. What look like two birds (economic sustainability and ecological sustainability) are really two different reflections of a single bird (sustainability). Thus ecological economists need to make a conscious effort to catch two birds in one hand, because it is the most effective way of assuring our collective actions and their success. The ARISE Program (African Rural Initiatives for Sustainable Environments) in South Africa provides a perfect example of how ecological restoration projects can provide opportunities for economic development and poverty reduction (box 14.1). The case study by James Blignaut and his colleagues presents an interesting look at how the South African government attempted, with mixed results, to help both the people and the environment of a densely populated rural village.

Back to the Future: Making Rational Collective Choices as Citizens

Throughout human history, people have shared knowledge and have made collective actions in order to survive. It is only in the last half century that we have lost the collective understanding (Norgaard 2004). As we argued earlier, human beings are self-interested consumers, but at the same time they are also citizens who are interested in

Box 14.1.
Ecological Restoration and Poverty Reduction

The Working for Water (WfW) program in South Africa, which started in 1995, is a public works program that aims to address three immediate challenges with one intervention: removing invasive plants, especially South American pompom weed (*Campuloclinium macrocephalum*), from riparian areas to improve the country's scarce water resources while providing jobs and economic empowerment to rural areas.

The WfW has grown into the single largest natural resource–based poverty relief and public works expenditure in a country where one out of every four adults is unemployed (Turpie, Marais, and Blignaut 2008). In 2005, the program employed thirty-two thousand people from diverse backgrounds (60 percent women, 20 percent youth, 2 percent disabled) on a budget of $66 million, and became one of the most often cited examples of restoration-oriented poverty relief by advocates of ecological restoration (Woodworth 2006). Restoration of natural ecosystems involves long-term investments in repeated removals of invasive species and reseeding of native species, which may not be sustainable if the program relies solely on government funding. To remain effective in this "ultralong distance race," the WfW compelled landowners to participate and share the costs by generating revenues and indirect benefits (Koenig 2009). The program also made possible the production of "eco-coffins" and school desks from the removed biomass, further generating economic opportunities in rural areas. By offering the "poorest of the poor" stable jobs manually clearing invasive plants in riparian areas, the program overcame the perception that ecological restoration is a middle-class affair and attracted broader support for conservation in the country (Woodworth 2006).

doing what is best for society. One of the fundamental principles of economics, "people respond to incentives," (Mankiw 2001) may prove to be useful here. We argue that at least some of the difficulties in carrying out collectively rational actions today are due to our current institutional setting that encourages us to behave as consumers. Understanding the social contexts of collective actions helps us design institutional and organizational settings that promote collective rationality as citizens and reduce the chance of unexpected decision failures, and also suggest the key areas of social research interests for postnormal ecological restoration studies.

Extensive literature about resource governance suggests that the motivation and success of collective actions when managing common-pool resources involves three dimensions: ecological sustainability, social equity, and economic efficiency (e.g., Hanna and Munasinghe 1995; Agrawal 2001). Although it is difficult to generalize the factors that promote success, in their meta study of community forest management, Pagdee, Kim, and Daugherty (2006) determined that the factors discussed most frequently as necessary for success were (1) well-defined property rights, (2) effective institutional arrangements, and (3) community interests and incentives. Decentralization, in which local communities are given management responsibility, authority, and recognition, also improves success through the development of clear ownership and tenure security. Farber et al. (2002) reviewed the case studies of environmental and government administration in Germany and suggested some necessary (although not sufficient) conditions that aid collective actions as citizens: (1) a functioning public with control over their government, that is, a public who forces all political actors to be advocates of justice and public interests; (2) individuals and groups who persistently work toward sustainable development; (3) a decentralized decision-making structure; and (4) an ethos of justice and the public interest. These studies showed that the success of collective action is possible when the institutional and organizational settings are set up in a way that provides benefits to participants, guarantees their rights, and facilitates responses to changing conditions (see chaps. 5, 6, 11, this volume, for discussion of these ideas).

Social relationships that enable learning and adaptation can be viewed as a type of asset (social capital) that includes associational activities, social relations, trust, and norms of reciprocity (Rudd 2000). Although social capital can be viewed as a by-product of voluntary or informal associations (i.e., through a heterarchy) (Crumley 1995), institutions and organizational structures can promote the development of trust and cooperation by increasing access to information and resources and by coordinating collective actions. As the concept of natural capital operationalizes the pursuit of sustainability, the concept of social capital can help us operationalize collective actions. One of the key structural variables of collective action is the existence of a socially constructed shared vision (Rudd 2000; also see chaps. 6, 16, this volume). In the absence of an omnipotent dictator, a shared vision must be constructed collaboratively, which is a slow process. As in ecological systems, social systems are sustained by conservative and slow-moving variables dynamically interacting with fast-moving factors. For sustainable management of both systems, we should focus our attention on the changes in slow variables while actively experimenting with fast ones (Holling, Gunderson, and Peterson 2002). In other words, iterative and aggressive social learning enabled by the shared vision is necessary for adaptive management (Lessard 1998).

On the other hand, when management focus is on increasing efficiency, social-economic systems can also accumulate slow-moving factors (e.g., centralization of decision-making power) and experience increased rigidity (e.g., conservatism and bureaucracy). Within a concentrated power structure, an erroneous course of actions can persist even after the negative consequences are realized and avoidable (Chermack 2004). Under these regimes, management tends to focus on maintaining constancy of the power structure while ignoring any signals to the contrary, rather than promoting adaptability in the face of unpredictable external changes. As in ecological systems, human organizations that are preoccupied with short-term gain and seek a series of easy "quick-fix" solutions tend to fail, while those that can learn and adapt to the external changes survive and proliferate in the long term (Makridakis 1991). In the business world, the leadership and integrity of a visionary CEO may guide a firm through uncertain times. In ecosystem management, there is no omnipotent dictator who can incorporate diverse, often conflicting values and guide us through a high degree of uncertainty and irreversibility in decisions with far-reaching and long-lasting consequences. The decisions have to be made collectively.

Collaborative social learning is also a way of reducing bounded rationality. There have been significant research efforts to develop participatory techniques and tools to overcome bounds in individual rationality and reach consensus through "futuring" (Frame and Brown 2008). For example, scenario planning is one of the social learning tools developed in management science. Scenario planning has gained credibility as an effective tool to prepare for an uncertain future, and the demand for such a tool has exploded in recent years (Chermack 2005; Peterson, Cumming, and Carpenter 2003). It is "a process of positing several informed, plausible and imagined alternative future environments in which decisions about the future may be played out, for the purpose of changing current thinking, improving decision making, enhancing human and organization learning and improving performance" (Chermack 2004). In other words, scenario planning is a process of asking a series of "what if" questions to reach an "Aha!" moment collectively. Each scenario as a story can hold vast information, help us identify and communicate the forces that shape our future, and learn about the weaknesses and strengths of our institutions. Through collective scenario-building exercises, we can dream effectively as a group to envision the future. In this context, planning is viewed as an iterative process where the goal is learning, rather than a one-time activity to make a rational and comprehensive decision.

There are varying degrees of reluctance among scientists and resource managers to accept or be open to the idea that we cannot have complete information about the very system we exist in (Ludwig 2001). The dynamic nature of ecosystems does not allow us to optimize around a single objective with predicted consequences of our management actions (Holling and Gunderson 2002). However, the urgency of the problems demands action now. Ecological economics and other social sciences can contribute significantly to the success of ecological restoration by clearly aiming to enable actions under high uncertainty. If failure is an inevitable natural process in both ecosystems and social-economic systems, the question to ask is, How can we design institutions and organizations to anticipate failures and minimize the negative consequences while learning from our collective mistakes and conserving the capacity to change? Ecological economists, by identifying incentives that motivate individuals to act as citizens to pursue collectively rational actions for ecological restoration, also have much to add to the already extensive literature about collective actions for managing common-pool resources. Moreover, they can help restorationists and stakeholders develop better techniques and tools for collective futuring and construction of a shared vision.

Conclusion

To generate broader support for ecological restoration and promote restorative actions, we need to openly acknowledge the uncertainty of the human situation and our inherent ignorance while emphasizing the need for a shared vision and continuous adaptive management based on social learning. In this chapter, we have made a case for ecological economics as a normative postnormal science. Although ecological economics has made substantial contributions to the developments of postnormal sustainability technologies (Frame and Brown 2008), people still have a long way to go before accepting postnormal science as an effective way of gaining knowledge and crafting public policy. According to Müller (2003), ecological economics itself is still at the crossroads between normal and postnormal science. We agree with Müller that the main strength of ecological economics is its focus on seeking solutions to imminent problems. If ecological economics is to remain as a revolutionary paradigm shift from neoclassical economics and not be absorbed into the mainstream economics as a branch, researchers must consciously examine the broader social relevance of their research questions and be clear about their aims and responsibilities.

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