Paying for Restoration

Karen D. Holl[1,2]
Richard B. Howarth[3]

Abstract

The question of how society is going to pay for restoration has received little open discussion. We review existing literature and examples to explore two questions: How should ecological and economic considerations be balanced in determining expenditures on restoration projects? and How is society going to pay for the substantial costs involved? We discuss a number of different techniques for determining the amount of money to allocate to restoration efforts, including ecosystem replacement costs, quantifying ecosystem services, contingent valuation, and surrogate market price techniques. We then review different strategies for paying for restoration including private funding by the party responsible for the damage, public funding through taxes, voluntary contributions, and various public/private partnerships. We conclude by discussing other considerations in developing strategies to pay for restoration, including uncertainty, timescale, evaluating success, and regional planning.

Key words: cost, ecological restoration, economics, ecosystem valuation, ecosystem services, environmental assurance bonding.

Introduction

In the field of restoration ecology numerous articles address the ecological obstacles to restoring damaged ecosystems and strategies for overcoming these obstacles. Little has been written, however, regarding the question of how society is going to pay for restoration strategies. Clearly, there are numerous ecological factors that slow ecosystem recovery, but as any land manager knows, the most common obstacle to restoration is obtaining sufficient funds to pay for it (King 1991). Although restoration costs are rarely documented in academic articles, it is clear that they are often extremely high (Edwards & Abivardi 1997). For example, the cost of the Kissimmee River Restoration Project is estimated to be $8 billion (Stevens 1999), and the price tag for the controversial Everglades restoration efforts is of similar magnitude (Enserink 1999).

This lack of attention to costs in the restoration literature may result from a number of factors. First, some people involved in ecological restoration, due to their belief in the inherent value of intact ecosystems, are averse to quantifying environmental values in economic terms. Such quantification may be interpreted as putting a price on ecosystem destruction. Second, economists and ecologists have traditionally approached the world from different disciplinary perspectives, using different models and language (Hall 1992). Third, as a result of these different approaches, as well as the fact that much ecological restoration is necessitated by past economic activities, restoration and economics are often viewed as opposing forces. In fact, in an article outlining the Society for Ecological Restoration's definition of restoration (Jackson et al. 1995), "economic or narrowly anthropocentric" values and "biocentric or enlightened anthropocentric values" are placed at two extremes. Fourth, it is difficult to discuss the economics of restoration since data on the costs of specific projects are difficult to obtain (Edwards & Abivardi 1997). Much restoration work is done by consultants who are rarely paid to publish their results and may choose not to make their data available.

Despite these obstacles, it is essential that insights from ecology and economics be brought together if restoration efforts are to succeed on a large scale. As Edwards and Abivardi (1997) articulately discuss, restoration ecologists must recognize that restoration activities "are inextricably embedded within an economic framework." As an ecologist and an economist, we aim to connect these disciplinary perspectives in an effort to explore the questions: How should ecological and economic considerations be balanced in determining expenditures on restoration projects? and How is society going to pay for the substantial costs involved? Edwards and Abivardi (1997) briefly discuss the first question and offer many insightful thoughts about melding economics and restoration. We extend this first discussion as a necessary introduction to the second question. We do not claim to have all the answers, but want to instigate discussion in this critical area.

It is important to clarify three decisions we have made in framing our discussion. First, the term restoration is used to refer to a wide spectrum of activities. These range from minimum permit compliance that may only require a given percent vegetation cover at a single time-point to attempts to restore a close representation of the original ecosystem structure and function in perpetuity. Although there has been much discus-

[1]Environmental Studies Department, University of California, Santa Cruz, CA 95064, U.S.A.
[2]Address correspondence to K. Holl.
[3]Environmental Studies Program, Dartmouth College, Hanover, NH 03755, U.S.A.

sion of appropriate terms to subdivide these activities (e.g., NRC 1992; Jackson et al. 1995; Bradshaw 1997), the term restoration still means different things to different people. Given the broad nature of our discussion, we include examples that span the range of restoring damaged ecosystems.

Second, we draw principally on examples from the United States, although most of the strategies and legislation discussed have parallels in other countries. Clearly, paying for ecological restoration is a global question, but to start this discussion we find it useful to focus on a country with a high level of financial resources and a relatively stable government. If the United States and other developed countries are unable to pay for restoration, it is difficult to imagine how countries with less resources will be able to do so.

Finally, society has to make difficult decisions on how to allocate limited financial resources to a range of environmental activities, such as ecosystem protection, pollution control, environmental education, and ecosystem restoration. Preventing ecological damage should be a first priority and is often much less expensive than restoring an ecosystem. But, given past and current human activities, we must address the question of how to pay for ecosystem restoration.

Evaluating the Costs and Benefits of Restoration

The first question we consider is how to integrate ecological and economic considerations in deciding the level of resources to allocate to restoration. Six methods that have been used for this purpose are discussed here (Table 1). In actuality, the amount of money allocated to restoration projects typically does not reflect a thorough analysis of the project's respective costs and benefits, but instead reflects a minimum amount necessary to reclaim ecosystems to some general criteria. For example, the Surface Mine Control and Reclamation Act of 1977 requires mined land to be revegetated, but revegetation success is often determined by percent ground cover and number of trees present without regard to species composition (Holl & Cairns 1994).

Replacement Cost. At first, the most obvious way to allocate funds to restoration projects appears to be estimating the restoration or replacement cost for the ecosystem. This approach rests on the implicit assumption that ecosystem health is highly valued by society and is not to be traded off against economic considerations. According to Pearce (1993), "The replacement cost approach is straightforward. If environmental damage is done, it is often possible to find out quite easily the cost of restoring the damaged environment." But, most people who have been involved with restoration projects would agree that this estimation is less simple than Pearce suggests. First, the different parties have to agree on what constitutes restoration in a given situation, which is often a highly contentious question (NRC 1992; Cross 1993; Mazzotta et al. 1994; Jackson et al. 1995; Bradshaw 1997). Second, as mentioned previously, costs of past projects are often difficult to obtain because they are rarely reported in the literature (Edwards & Abivardi 1997). Third, estimated project costs often fail to account for the resources required to support planning and permitting, volunteer labor, monitoring, overhead, and facilities (Guinon 1989). Finally, many projects experience cost overruns given the need to adapt preconceived plans to actual circumstances.

Replacement Cost Multiplier. To cope with such uncertainties, project planners and decision makers may scale up their best estimate of restoration costs to account for contingencies (Heyde 1995). The use of cost multipliers is linked to U.S. environmental laws, such as the Comprehensive Environmental Response, Liability, and Compensation Act (CERCLA, or the "Superfund") and the Oil Pollution Act of 1990 (OPA), which require polluters to cover the cost of restoring publicly owned resources that are damaged by their activities. Such statutes mandate the restoration of ecosystem functions to baseline levels, while also requiring polluters to compensate the public for irreparable damages and for the services lost during the process of ecosystem recovery (Mazzotta et al. 1994; Heyde 1995). A number of statutes in fields such as consumer protection, antitrust, and trademark and patent law make use of damage multipliers (typically by a factor of 2 or 3) to cope with intangibles and uncertainties in cost estimation (Dobbs 1993; Heyde 1995).

Valuing Ecosystem Goods and Services. Although explicit legal requirements to return damaged ecosystems to baseline functioning would be desirable from an ecological perspective, from an economic perspective it is important to know whether restoration costs generate environmental benefits of equal or greater magnitude. If the benefits of a project exceed its costs, and the net benefits are equitably distributed between members of society, then the project is said to enhance "social welfare" in the sense that it promotes the satisfaction of people's preferences. Increasingly, decision makers are recognizing the goods and services that are provided by relatively intact ecosystems, such as flood control, maintenance of soil fertility, minimization of soil erosion, and pest control (Costanza et al. 1997; Daily 1997). Although such services are often difficult to quantify, they are increasingly being used to justify the commitment of resources to restoration projects.

For example, van Wilgen and colleagues (1996) found that an exotic plant eradication program in a South Af-

Table 1. Methods for evaluating the costs and benefits of ecological restoration.

Method	*Description*
Replacement cost	Cost of restoring a damaged ecosystem
Replacement cost multiplier	Cost of restoring an ecosystem plus additional funding for lost values during damage and uncertainty
Valuing ecosystem goods and services	Evaluate economic benefits of restoring a given good or service using a tradeable substitute, e.g., watershed for restoration vs. a water treatment plant to improve water quality
Contingent valuation	Evaluate amount to allocate based on surveys of peoples' willingness to pay for a restored area
Travel cost method	Estimate the value that people place on a site by their willingness to spend time and money traveling to an area
Hedonic price method	Estimate the value of a restored area by evaluating the effect of a restored area on nearby property values

rican fynbos ecosystem generated water quality benefits that far exceeded the direct costs of program implementation. In this case, ecological restoration forestalled the need to construct expensive water storage and treatment facilities. Likewise, in 1996 New York City invested \$1–1.5 billion to restore a watershed in the Catskill Mountains to improve water quality, rather than building a \$6-8 billion filtration plant (Chichilnisky & Heal 1998). This approach of quantifying both direct use values (products harvested from the ecosystem) and indirect use values (ecosystem functions) serves to justify an amount of money to dedicate to restoration in narrow economic terms. This method, however, overlooks so-called "existence values," which involve aesthetics, community pride, and a sense of stewardship, in part from the direct enjoyment of an ecosystem and its products. Such values, of course, are a primary motivation behind environmental laws and management practices.

Contingent Valuation. The technique of contingent valuation has been used to quantify all of the values people place on ecosystems, including existence values. In contingent valuation, survey instruments are used to ascertain people's willingness to pay to maintain or restore an ecosystem (Pearce 1993; Heyde 1995). This approach has been employed to estimate the benefits of preserving a local wetland in Kentucky (Whitehead 1990) and restoring hedgerows and wetlands in Lower Normandy, France (Bonnieux & Le Goffe 1997). Each of these projects was financed by taxpayers, and the studies in question found that tax increases yielded more than proportionate environmental benefits.

Although contingent valuation has been lauded as the only approach that includes both use and nonuse values, it has also been criticized on a variety of grounds (Knetsch 1990; Cross 1993; Vatn & Bromley 1994; Heyde 1995; Carson 1998). According to critics, the usefulness of contingent valuation is clouded by: people's inexperience in making quantitative evaluations of how much they would be willing to pay for nonmarket environmental goods; research findings that people often give approximately the same answer, \$5-10 per month, regardless of the size or significance of the issue; apparent discrepancies between peoples' stated willingness to pay and their observed actions; and effects of people's relative income on their responses. Practitioners have partially addressed these problems by clearly defining both the project and its financing mechanism and by asking people to rank different conservation alternatives to relativize their importance (Dixon & Sherman 1990; Pearce 1993; Carson 1998). Nonetheless, not all economists accept the legitimacy of contingent valuation methods.

Travel Cost and Hedonic Price Methods. The final set of approaches that have been used to estimate the value of conserving and restoring natural areas attempt to estimate peoples' willingness to pay through surrogate market prices: the travel cost method and hedonic pricing (Dixon & Sherman 1990; Pearce 1993). In the travel-cost method, peoples' willingness to pay to preserve or restore a recreational area is estimated from the time and money actually spent in traveling to the site, including meals, lodging, entrance fees, and equipment. For example, Wilson and Carpenter (1999) reviewed a number of studies that quantified the value of improving water quality in lakes and rivers using the travel cost method. Hedonic pricing considers the effects of improved or degraded environmental quality on the value of housing or land. For example, proximity to and increasing proportion of nearby land covered by urban forests may increase property prices (Tyrväinen 1997).

These approaches have not been widely used thus far to estimate the economic benefits of restoration and are only useful in certain situations. But, it is possible that they will be used increasingly in the future. For example, a developer in the Santa Cruz, California area has spent a great deal of money over the past 10 years removing exotic species to allow for recovery of native plants on a 30-ha landholding that he intends to develop in 2.5-ha lots (M. Shaw 1997, personal communication). He has spent this money because of his speculation that the value of the land will increase due to the native vegetation. Indeed, quite substantial evidence suggests that home buyers are willing to pay a premium price to purchase properties with desirable environmental amenities.

To conclude this section, each of the methods outlined above for evaluating the costs and benefits of restoration efforts has strengths and weaknesses. The most appropriate method to use depends on numerous factors, such as the magnitude of the costs and who is paying for the restoration. For example, when there is a clear individual party causing the damage, ideally, this party would be charged the full cost of restoring the system to a close resemblance of the predisturbance state, whereas taxpayers may measure the benefits of ecosystem services or use contingent valuation to determine an acceptable contribution to restoration. As stated at the outset, the amount of money allocated for restoration is usually less than would be desired. Considering different methodologies for valuing restored ecosystems, however, provides incentives to allocate additional money to restoration efforts.

Assigning Responsibility for Restoration Costs

Arguably the most overlooked question in restoration ecology is who is going to pay for restoration. Of course, one intuitive response to this question is "whoever caused the damage" otherwise known as "the polluter pays principle" (Costanza & Cornwell 1992). We begin our discussion (outlined in Fig. 1) by considering the case in which a single large party has caused or will cause clear harm to publically owned resources. In such instances, efforts have focused on legislation to ensure that the responsible party is accountable for the full costs of environmental damage and restoration. Ideally, this accountability should be secured before the environmental damage takes place through frameworks such as environmental assurance bonding (Costanza & Perrings 1990; Costanza & Cornwell 1992). Under this mechanism, responsible parties post bonds that can be used to pay restoration costs if they default on their commitment to return an ecosystem to some specified condition; if the party meets its obligation then the bond is released. This model has been used with respect to coal surface mine legislation in the United States (McElfish & Beier 1990). The Surface Mine Control and Regulation Act of 1977 (SMCRA) requires companies to post a bond prior to mining; the money is released after a certain period of time, usually 5-10 years, if the mine has been reclaimed to meet prevailing regulatory standards.

Other statutes in the United States have taken different approaches to achieve the same end of assigning economic responsibility for environmental damage and associated restoration costs. Under CERCLA, for example, the U.S. government has attempted to levy fines after the fact to make companies pay for the clean-up of toxic wastes. Recovering damages for past environmental harms has proven problematic since it is often difficult and/or costly to determine responsibility (Mazmanian & Morell 1992; Cross 1993). In some cases legislation aims to assign responsibility before damage is done. For example, Habitat Conservation Plans (HCPs) are increasingly being used to allow land owners to "take" species protected by the U.S. Endangered Species Act (Noss et al. 1997; Hood 1998). The land owners are required to make efforts to mitigate for this taking; such mitigation procedures often include restoration of degraded habitat. The means for ensuring financial responsibility varies with the individual HCP.

As is demonstrated by many of the previous examples, there is a trend toward assigning responsibility for environmental damage and restoration costs. With all these approaches to paying for restoration, the first question we discussed arises: What share of the costs of a given project should be paid by a single party? This question has arisen particularly with respect to environmental assurance bonding. Ideally, the cost of the bond would cover the "worst case scenario" (Costanza & Perrings 1990), but in reality the value of bonds that are posted is often quite low, making it fiscally more attractive for the landowner to default in some cases (McElfish & Beier 1990). And, criteria for judging success are often far short of restoring an ecosystem close to that prior to disturbance. For any of these approaches to work, the financial responsibility or incentive has to be sufficiently large to ensure a reasonable attempt to restore the ecosystem.

If ecological systems are viewed as public property then ideally the responsible party should pay for restoration. In practice, however, this principle is often difficult to apply for a few reasons. First, in many cases the damage was done sufficiently long ago that it is difficult to identify the responsible party. Much of the CERCLA funding in the first few years was spent trying to identify responsible parties (Mazmanian & Morell 1992). Second, much environmental damage is caused by cumulative effects of many small businesses or individuals. For example, urban runoff often contains high levels of a variety of nonpoint source pollutants that are hard to control, such as animal feces, motor oil, and lawn fertilizers (Novotny & Olem 1994); to restore urban streams requires corrective actions to improve water quality. Third, it is often difficult to pinpoint any responsible party. In California, much restoration work is focused on exotics removal (e.g. Fritzke & Moore 1998; Holloran 1998; Kan 1998). Who is responsible for invasive plants such as iceplant (*Carpobrotus edulis*) and French broom (*Genista monspessulana*) that are ubiqui-

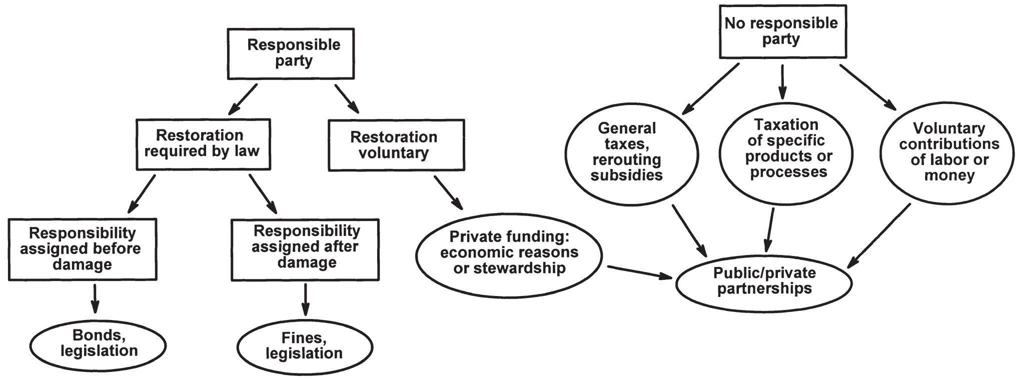

Figure 1. Assigning responsibility for restoration costs.

tous in the landscape? Given the fact that it is often difficult to assign direct causality for the need for restoration, we must consider how to pay for restoration in these cases (Fig. 1).

The most commonly used approach to pay for restoration without a single responsible party is some form of taxation. In some cases specific raw and manufactured materials are taxed to reflect their overall environmental costs. For example, excise taxes from the sale of fishing equipment and motorboat and small engine fuels are being used for acquisition and restoration of coastal marshes under the National Coastal Wetlands Conservation Grant Program of the United States Fish and Wildlife Service. Likewise, under SMCRA, money from a tax on coal is used to reclaim abandoned mined land (McElfish & Beier 1990). This approach serves to internalize what are commonly considered environmental externalities and provides a price for a given product that more accurately reflects its true environmental cost (Pearce 1993).

Many large-scale restoration projects are paid for by general taxes that do not target the specific cause of destruction. The massive Kissimmee River Restoration project in Florida is primarily supported by taxpayers' money at both the national and state level (Toth & Aumen 1994). In this case the original damage was caused by the Army Corps of Engineers with taxpayers' money. Similarly, the Coastal Wetlands Planning, Protection, and Restoration Act of 1990, which provides funding for wetland preservation and restoration primarily in Louisiana, is financed by general taxes at the state and national level (Good 1993). The damage to wetlands in this region is largely a result of altered hydrology resulting from flood control, navigation, and mineral extraction projects (Good 1993). These ecosystems are critical to the economy of this region because these wetlands support over 30% of United States fisheries and 40% of the fur harvest (Federal Register 1990 vol. 101–375, p. 1–14).

This approach of taxpayer-supported restoration can be criticized for the fact that it does not target the responsible party or product produced. As discussed previously, however, a responsible party is often difficult to identify. Moreover, these costs may often be justified as restoration projects often provide ecosystem services to society as a whole. For example, giving tax breaks to farmers to take land near waterways out of production and to install vegetative buffer strips results in a net gain to nearby residents in the form of improved drinking water quality, flood control, and recreation (Rein 1999). Similarly, efforts to restore tropical forests, funded by the Global Environmental Facility of the United Nations and the World Bank (GEF 1998), benefit citizens of the developed countries that fund this program by providing a net sink for CO_2 and maintaining biodiversity that may provide important benefits in the future. Finally, in many cases such funding may not result in new taxes, but rather rerouting of subsidies away from financially damaging practices (Shabman 1995; Mountford & Keppler 1999). For example, in the Pacific Northwest of the United States money that was once used for logging is now being used to retrain loggers to work on riparian restoration projects (Ellison 1995). Likewise, funding that was once used to subsidize coastal development is now being used to acquire, protect, and restore coastal habitats (Valdes-Cogliano 1998).

Another way that many restoration projects are funded is through voluntary donations of money and, often, labor. Private individuals, for a range of personal reasons, may contribute directly or indirectly to nonprofit organizations that are involved in restoration on private or public lands. For example, The Nature Conservancy (TNC) has devoted a great deal of money and volunteer labor to longleaf pine/wiregrass restoration on their lands in Florida, with additional support from the U.S. government (Seamon 1998). Likewise, TNC has provided funding for acquisition and restoration of ~1,000 ha of riparian forest along the Sacramento River in California (D. Peterson 1999, personal communication). Recently, the William Penn Foundation donated $26.6 million to an urban park in Philadelphia, primarily for restoration and environmental education (Goldenberg 1999).

But monetary contributions are only part of the donations. Berger (1985) discusses many examples of projects initiated by, and often largely resulting from, volunteer labor. The number of volunteer-based restoration programs has exploded in the last 10 years, as evidenced by the numerous workshops on this topic at recent Society for Ecological Restoration meetings. It is not unusual for an individual park to record 100,000 volunteer hours in a year (Holloran 1996, personal communication; Goldenberg 1999) which even with a conservative estimate of $10/hr translates into $1 million in labor. The importance of community involvement in restoration projects cannot be underestimated in terms of education and developing a sense of stewardship (Holloran 1996; Geist & Galatowitsch 1999).

Restoration projects are often funded by different combinations of public and private contributions. Private land owners may undertake restoration projects on their own land for economic reasons or a sense of stewardship. For example, some ranchers in Colorado have voluntarily undertaken cattle management practices to allow for the recovery of riparian ecosystems (Cairns & Pratt 1995). Such efforts are increasingly being encouraged by providing public matching funds. Under the "Partners for Fish and Wildlife Program" of the U.S. Fish and Wildlife Service, the government will provide up to 50% matching funds to private land owners who voluntarily undertake restoration projects on their lands (USFWS 1999). Through this program an estimated 18,700 ha of wetlands, 20,700 ha of prairie and grasslands, and 690 km of riparian habitat were restored in 1998 alone (USFWS 1999). Increasingly, private conservation organizations are paying land owners to put lands in conservation easements that limit agricultural and development activities to protect and allow for the recovery of lands (Boyd & Simpson 1999). Likewise, in Costa Rica landowners are given tax breaks for reforesting logged land with native tree species (Butterfield & Fisher 1994).

In many cases, these partnerships reflect most accurately who benefits from these programs—both private individuals/corporations and the general public. For example, the invasion of zebra mussels into the Great Lakes has cost billions of dollars in the form of lost fisheries income and blockage of intake systems of municipal water supplies and power plant cooling systems (Mills et al. 1994); therefore, zebra mussel control is of economic interest to both private entities and the public, as well as ecological concern. These partnerships have other benefits. First, they encourage a pooling of resources and exchange of information between different groups involved in restoration. Moreover, more of the funds are likely to be spent on restoration efforts, rather than on extensive legal fees in assigning responsibility to private owners under the more traditional approaches discussed previously.

Closing Considerations

We have discussed different means for considering ecological and economic factors in the evaluation of restoration projects and ways of assigning financial responsibility for these projects. Clearly, the answers to these questions are dependent upon the specific situation. Regardless of the situation, however, a number of questions arise when one tries to develop rational, standardized criteria on how to pay to restore dynamic ecosystems.

Uncertainty and Time Scale. Probably the most difficult question in assigning responsibility and costs is uncertainty. As any ecologist knows, it is difficult to predict the time scale of ecosystem recovery given probabilistic events such as extreme weather conditions, pest outbreaks, and seed dispersal coupled with limited scientific knowledge. Ideally, although it is often not the case, environmental regulations would aim to prevent environmental damage (the precautionary principle) or prepare for the worst case scenario (Costanza & Cornwell 1992). Regardless, the question remains: How much money should a land owner be held responsible for? An excellent example of this conflict between ecological uncertainty and the need for financial predictability is the argument over the "no surprises clause" in Habitat Conservation Plans. This clause relieves land owners of additional restoration or other compensatory costs that may arise due to new knowledge or unexpected circumstances (Noss et al. 1997; Hood 1998). Given that these occurrences are ubiquitous, the no surprises clause transfers the financial responsibility for uncertainty to the public (Noss et al. 1997; Hood 1998).

In order for restoration efforts to succeed over the long term, we need to develop mechanisms that recognize uncertainty. First, restoration cost estimates should incorporate additional funds to cover additional costs that almost always arise. Even with more realistic cost estimates there will be some unexpected restoration failures due to extreme climatic conditions or other unexpected occurrences. One mechanism to cover such costs would be to require that groups causing environmental damage purchase "restoration insurance" which would cover restoration costs in the case of unexpected ecological conditions. Another method to compensate for unexpected restoration failures would be a general tax, which could be considered as an "intergenerational environmental security tax." Present generations would be taxed to ensure a certain level of environmental quality for the next generation as mandated by the concept of ecological sustainability.

A related question is how long a party should be held responsible for restoration. Usually the success of reclamation is judged after a relatively short period of time compared with that of natural ecosystem recovery; for example 5 years is common for judging the success of mine reclamation in eastern hardwood forests. This difference in ecological and political time scales presents a major obstacle to legislating and financing restoration (NRC 1992). Ideally, land owners would be held responsible in perpetuity, but in reality, as with the no surprises clause, long-term financial responsibility usually falls on the taxpayers.

Measuring Success. If parties are held financially responsible for restoring a damaged ecosystem, how does one judge whether they have succeeded in their efforts and should be relieved of fiscal responsibility? When restoration efforts are focused on a single species, developing metrics for success may be fairly straightforward. But, developing criteria for measuring restoration of ecosystem structure and function has been notoriously difficult. Scientists need to continue to work on these questions of developing community metrics to evaluate restoration. From a policy perspective, it is essential to require monitoring as part of the restoration project, and include associated monitoring costs in the price of the project. In many cases, monitoring is not done due to lack of funding.

Regional Allocation of Funds. Throughout this article we have referred to restoration projects on a case-by-case basis. When there is a party clearly responsible for a damage to public resources, it is important to designate responsibility at this scale. But, when the costs fall to society in general, there will necessarily have to be prioritization of projects, given limited funds. This means that in paying for restoration we need to assess the relative costs and benefits of restoration projects on a regional scale. For example, with the Coastal Wetlands Planning, Protection and Restoration Act there is a planning group comprised of local, state, and federal government agencies, private groups, scientists, and the public (Good 1993). Each year the planning committee prioritizes project proposals based on their ecological importance and cost effectiveness; the proposed projects are reviewed at public hearings and ultimately approved by the state legislature and U.S. Congress. Similarly, the U.S. Environmental Protection Agency has funded research to develop techniques for prioritizing riparian restoration projects based on ecological and land-use considerations (Kentula 1997). This type of regional planning process is essential given limited funds.

Recommendations. As our discussion makes clear, assigning responsibility for paying for restoration depends on various social and ecological contexts in which restoration takes place. Certainly restoration projects will continue to be paid for by a range of sources. In closing, we reiterate a few previous points that are particularly important to ensuring that adequate funding is available for restoration efforts. First, we must continue to develop methods for quantifying ecosystem services to demonstrate the economic value of both intact and restored ecosystems. Second, restoration practitioners should make accurate restoration costs publicly available. Without such figures it is impossible to know the amount of resources to allocate. Third, we need to develop institutional mechanisms for addressing questions of uncertainty and timescale in funding projects. Finally, we need to bring people with a range of skills and backgrounds, such as ecologists, economists, land managers, policy makers, and people trained in risk management, together to dialogue about strategies to pay for restoration both in general and specific cases.

Acknowledgments

Discussions with students in our spring 1998 graduate seminar were helpful in synthesizing our ideas. We appreciate comments from G. Daily, B. Haddad, J. Heckman, and S. Ryan on an earlier draft of the manuscript.

LITERATURE CITED

Berger, J. J., editor. 1985. Restoring the earth: how Americans are working to renew our damaged environment. Island Press, Washington, D.C.

Bonnieux, F., and P. Le Goffe. 1997. Valuing the benefits of landscape restoration: a case study of the Cotentin in Lower-Normandy, France. Journal of Environmental Management **50:**312–333.

Boyd, J., and R. D. Simpson. 1999. Economics and biodiversity conservation options: an argument for continued experimentation and measured expectations. Science of the Total Environment **240:**91–105.

Bradshaw, A. 1997. What do we mean by restoration? Pages 8–16 in K. M. Urbanska, N. R. Webb, and P. J. Edwards, editors. Restoration ecology and sustainable development. Cambridge University Press, New York.

Butterfield, R. B., and R. F. Fisher. 1994. Untapped potential for native species reforestation. Journal of Forestry **92:**37–40.

Cairns, J., Jr., and J. R. Pratt. 1995. Ecological restoration through behavioral change. Restoration Ecology **3:**51–53.

Carson, R. T. 1998. Valuation of tropical rainforests: philosophical and practical issues in the use of contingent valuation. Ecological Economics **24:**15–29.

Chichilnisky, G., and G. Heal. 1998. Economic returns from the biosphere. Nature **391:**629–630.

Costanza, R., and L. Cornwell. 1992. The 4P approach to dealing with environmental uncertainty. Environment **34:**12–20, 42.

Costanza, R., and C. Perrings. 1990. A flexible assurance bonding system for improved environmental management. Ecological Economics **2:**57–75.

Costanza, R., R. d'Arge, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature **387:**253–260.

Cross, F. B. 1993. Restoration for natural resource damages. University of Toledo Law Review **24:**319–334.

Daily, G. C., editor. 1997. Nature's services: society's dependence on natural ecosystems. Island Press, Washington, D.C.

Dixon, J. A., and P. B. Sherman. 1990. Economics of protected areas: a new look at benefits and costs. Island Press, Washington, D.C.

Dobbs, D. B. 1993. Law of remedies: damages-equity-restitution. 2nd Edition. West Publishing Co., St. Paul, Minnesota.

Edwards, P. J., and C. Abivardi. 1997. Ecological engineering and sustainable development. Pages 325–352 in K. M. Urbanska, N. R. Webb, and P. J. Edwards, editors. Restoration ecology and sustainable development. Cambridge University Press, New York.

Ellison, D. 1995. President's council on sustainable development. Proceedings of the Society for Ecological Restoration 1995 Conference: 92.

Enserink, M. 1999. Plan to quench the Everglade's thirst. Science **285:**180.

Fritzke, S., and P. Moore. 1998. Exotic plant management in national parks of California. Fremontia **26:**49–53.

Geist, C., and S. M. Galatowitsch. 1999. Reciprocal model for meeting ecological and human needs in restoration projects. Conservation Biology **13:**970–979.

Global Environmental Facility (GEF). 1998. Project implementation review of the global environmental facility 1997. http://www.gefweb.org/assets/images/report.doc. (March 11, 1999).

Goldenberg, N. 1999. Philadelphia launches major restoration initiative in park system. Restoration and Management Notes **17:**8–14.

Good, B. 1993. Louisiana's wetlands. Restoration and Management Notes **11:**125–133.

Guinon, M. 1989. No free lunch. Restoration and Management Notes **7:**56.

Hall, C. A. S. 1992. Economic development or developing economics: what are our priorities? Pages 101–126 in M. Wali, editor. Ecosystem rehabilitation.Vol. I. SPB Academic Publishing Inc., The Hague, Netherlands.

Heyde, J. M. 1995. Is contingent valuation worth the trouble? Chicago Law Review **62:**331–362.

Holl, K. D., and J. Cairns, Jr. 1994. Vegetational community development on reclaimed coal surface mines in Virginia. Bulletin of the Torrey Botanical Club **121:**327–337.

Holloran, P. 1996. Greening the Golden Gate. Restoration and Management Notes **14:**112–123.

Holloran, P. 1998. Deliberate amateurs: volunteers and exotic pest plant control. Fremontia **6:**73–75.

Hood, L. C. 1998. Frayed safety nets: conservation planning under the Endangered Species Act. Defenders of Wildlife, Washington, D.C.

Jackson, L. L., N. Lopoukhine, and D. Hillyard. 1995. Ecological restoration: a definition and options. Restoration Ecology **3:**71–75.

Kan, T. 1998. The Nature Conservancy's approach to weed control. Fremontia **26:**44–48.

Kentula, M. E. 1997. A step toward a landscape approach in riparian restoration. Restoration Ecology **5 (suppl.):** 2–3.

King, D. M. 1991. Costing out restoration. Restoration and Management Notes **9:**15–21.

Knetsch, J. L. 1990. Environmental policy implications of disparities between willingness to pay and compensation demanded measures of values. Journal of Environmental Economics and Management **18:**227–237.

Mazmanian, D. A., and D. Morell. 1992. Beyond superfailure: America's toxics policy for the 1990s. Westview Press, Inc., Boulder, Colorado.

Mazzotta, M. J., J. J. Opaluch, and T. A. Grigalunas. 1994. Natural resource damage assessment: the role of resource restoration. Natural Resources Journal **34:**153–178.

McElfish, J. M., and A. E. Beier. 1990. Environmental regulation of coal mining. Environmental Law Institute, Washington, D.C.

Mills, E. L., J. H. Leach, J. T. Carlton, and C. L. Secor. 1994. Exotic species and integrity of the Great Lakes. BioScience **44:** 666–676.

Mountford, H., and J. H. Keppler. 1999. Financing incentives for the protection of biodiversity. Science of the Total Environment **240:**133–144.

National Research Council (NRC). 1992. Restoration of aquatic ecosystems. National Academy Press, Washington, D.C.

Noss, R. F., M. A. O'Connell, and D. D. Murphy. 1997. The science of conservation planning. Island Press, Washington, D.C.

Novotny, V., and H. Olem. 1994. Water quality: prevention, identification, and management of diffuse pollution. Van Nostrand Reinhold, New York.

Pearce, D. W. 1993. Economic values and the natural world. MIT Press, Boston, Massachusetts.

Rein, F. A. 1999. An economic analysis of vegetative buffer strip implementation. Coastal Zone Management **27:**377–390.

Seamon, G. 1998. A longleaf pine sandhill restoration in northwest Florida. Restoration and Management Notes **16:**46–50.

Shabman, L. A. 1995. Making watershed restoration happen: what does economics offer? Pages 35–47 in J. Cairns, Jr., editor. Rehabilitating damaged ecosystems, 2nd Edition. CRC Press, Boca Raton, Florida.

Stevens, W. K. 1999. Some scientists attack plan to restore Everglades. New York Times. http://www.nytimes.com/library/national/science/022299sci-everglades-environ.html (Feb. 22, 1999).

Toth, L. A., and N. G. Aumen. 1994. Integration of multiple issues in environmental restoration and resource enhancement projects in south/central Florida. Pages 61–78 in J. Cairns, Jr., T. V. Crawford, and H. Salwasser, editors. Implementing integrated environmental management. Virginia Polytechnic and State University Center for Environmental and Hazardous Materials Studies, Blacksburg, Virginia.

Tyrväinen, L. 1997. The amenity value of the urban forest: an application of the hedonic pricing method. Landscape and Urban Planning **37:**211–222.

United States Fish and Wildlife Service (USFWS). 1999. Partners for Fish and Wildlife Program. Cumulative accomplishments. http://www.fws.gov/r9dhcpfw/ACCOMPS/Accomps.htm. (March 11, 1999).

Valdes-Cogliano, S. 1998. FWS coastal habitat programs. Endangered Species Bulletin **23:**18–19.

van Wilgen, B. W., R. M. Cowling, and C. J. Burgers. 1996. Valuing of ecosystem services. Bioscience **46:**184–189.

Vatn, A., and D. W. Bromley. 1994. Choices without prices without apologies. Journal of Environmental Economics and Management **26:**129–148.

Whitehead, J. C. 1990. Measuring willingness-to-pay for wetlands preservation with the contingent valuation method. Wetlands **10:**187–201.

Wilson, M. A., and S. R. Carpenter. 1999. Economic valuation of freshwater ecosystem services of the United States: 1971-1997. Ecological Applications **9:**772–783.