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Restoration and Economics: A Union Waiting to Happen?

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Abstract

In this article, our objective is to introduce economics as a tool for the planning, prioritization, and evaluation of restoration projects. Studies that develop economic estimates of public values for ecological restoration employ methods that may be unfamiliar to practitioners. We hope to address this knowledge gap by describing economic concepts in the context of ecological restoration. We have summarized the most common methods for estimating the costs and benefits of restoration projects as well as frameworks for decision analysis and prioritization. These methods are illustrated in a review of the literature as it applies to terrestrial restoration in the United States, with examples of applications of methods to projects. Our hope is that practitioners will consider collaborating with economists to help ensure that restoration costs and benefits are identified and understood.

Key words: **benefits, costs, economics, ecosystem services, nonmarket valuation, restoration.**

Introduction

Over the past 20 years, ecological restoration has emerged as an important component of ecosystem management and environmental protection. Many restoration projects take place in areas with surrounding human communities; understanding how society values improvements to ecosystems can improve the effectiveness of these projects. Yet the restoration literature recognizes that the public values of restoration are not well understood (Weber & Stewart 2009) and that the socioeconomic aspects of restoration are "underemphasized, or often ignored altogether" (Aronson et al. 2010). There are a variety of economic tools available to incorporate social values when evaluating restoration projects. The lack of familiarity of these tools among practitioners, along with a misconception that the primary goal of economists is to maximize monetary value, has led to challenges in developing a mutually intelligible language between the fields of economics and ecology (Simpson 1998; Holmes et al. 2004). Economics provides a suite of tools for informing decision-making and potentially improving transparency when choosing between projects. Integrating economics into planning and implementation can improve a project's effectiveness by allocating limited budgets and resources where they will do the most good.

With this article, our objective is to describe economic tools that can be applied to guide planning, prioritization, and evaluation of restoration projects, and to demonstrate their application using examples from the restoration literature. We begin by describing the concept of economic value, and follow with a brief overview of methods used to estimate such values. We then summarize the process for selecting the articles used as examples from the restoration literature. We describe estimating restoration benefits with a focus primarily on nonmarket methods and then discuss the problem of identifying and accounting for costs. We conclude with a review of decision-analysis frameworks for evaluating projects and suggestions for integrating economic analysis into restoration projects. Although previous articles have featured either meta-analyses of existing studies or reviews of individual methods, we seek to present a spectrum of valuation techniques and discuss frameworks that can aid in the evaluation of tradeoffs associated with management alternatives.

Economic Value

In economics, the term "value" implies a good or service has worth, because it is scarce or has utility to people; in turn, people are willing to make a tradeoff for that good or service. Several billion dollars are spent annually on restoration projects in the United States alone (Bernhardt et al. 2005; GAO 2008). If society is willing to make such large expenditures on restoration efforts, then the ecosystem benefits and services improved through such efforts clearly have value. However, it can be difficult to describe and quantify the full value of restoration because many ecosystem benefits and services are not bought and sold in existing markets. For many ecosystem services, markets simply do not exist. With no market data or prices, these services are often misrepresented in

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discussions about choices and tradeoffs associated with different types and levels of restoration.

There is considerable philosophical debate in the literature about using anthropocentric approaches to value nature (Goulder & Kennedy 2010). Many believe that ecosystems have intrinsic value that is independent of any contribution to human well-being (Hobbs et al. 2004; Aronson et al. 2007). There is concern about prioritizing human preferences given how much they vary by context and ignore issues of equity and distribution (Sagoff 1994; Vatn & Bromley 1994). Additionally, even when viewed from an anthropocentric approach, policy choices that result in an increase in net monetary benefits may not necessarily result in an increase in social welfare, suggesting a need for distributional weights to address equity effects (Persky 2001).

The Millennium Ecosystem Assessment (MA 2003) provides a conceptual framework for evaluating environmental values primarily using indicators for ecosystem condition, services, human well-being, and drivers of change. We focus on approaches that define benefits through willingness to pay (WTP) and costs through willingness to accept (WTA) because current peer-reviewed literature predominantly uses these methods to quantify the benefits and services provided by ecosystems.

One framework for visualizing the full range of social values generated from restoration is the concept of total economic value (TEV) (Fig. 1). TEV distinguishes between use and non-use values for estimating the full economic value of a good or service (NRC 2005); similarly, the MA (2003) categorizes ecosystem services as provisioning, regulating, cultural, or supporting, which overlap with use and non-use values (see Fig. 1 for comparison of classifications). Use values include direct and indirect values. Direct values can be quantified by examining production or consumption of commercial goods such as fish or timber, and recreational opportunities or aesthetics for property owners. Indirect use values include those that indirectly contribute to societal welfare, such as clean air, flooding and erosion control, and stormwater management. Non-use values include option, bequest, and existence values. Each type of value may require a different type of estimation method.

Estimation Methods

Methods to estimate use and non-use values can be categorized as market or nonmarket approaches. Direct use values are often estimated using market methods. Market methods rely on market data, making them somewhat easier to apply than nonmarket methods. Nonmarket approaches generally derive value estimates from observed or hypothetical behavior. Nonmarket techniques are used widely to estimate both direct and indirect use values, as well as non-use values. The choice of which valuation method to use depends on the project itself, as well as budget, timeline, and data requirements. There are numerous resources available to readers interested in more information about theoretical and methodological approaches to estimating use and non-use environmental values (Champ et al. 2003; Freeman 2003; Tietenberg 2009).

Literature Selection

We used the keywords "economics" and "restoration" to search peer-reviewed journals focusing on restoration, conservation biology, and environmental, natural resource or ecological economics. The search initially produced 1,426 hits from 15

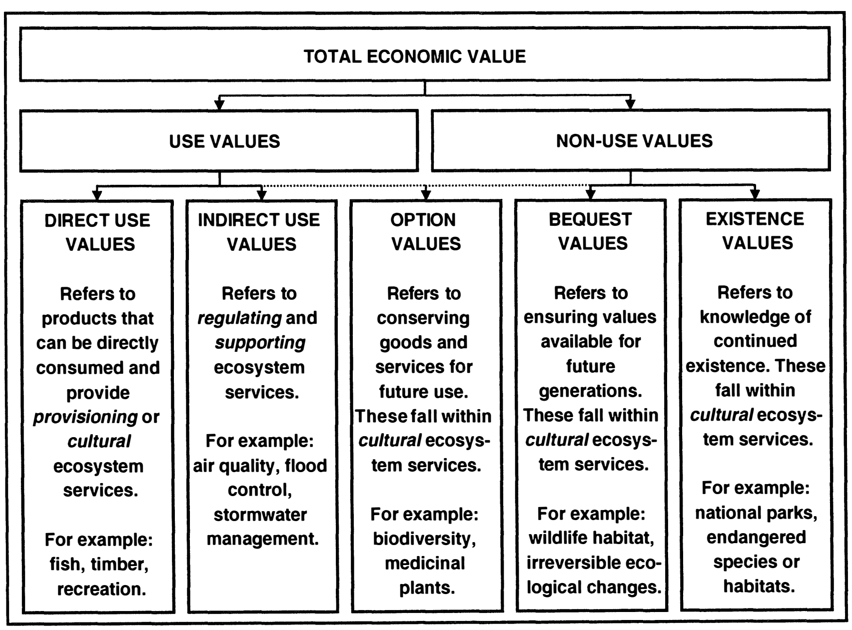

Figure 1. Total economic value. Terms in italics refer to Millennium Ecosystem Assessment terminology for ecosystem services.

journals. We then limited the search to studies completed in the last decade (2000–2010) focusing on terrestrial systems in the United States. Aronson et al. (2010) found that restoration projects in terrestrial systems were comparatively under-represented in the literature, which emphasizes aquatic restoration. Not all types of methodology were represented in peer-reviewed journal articles; we conducted a secondary search among institutions or organizations engaging in restoration activities. This resulted in approximately 100 articles describing recent efforts to quantify the value of specific terrestrial restoration projects (Appendix). Examples in the text were selected to illustrate applications using the range of valuation methods.

Estimating Restoration Benefits

Several techniques have been developed to estimate the value of nonmarket benefits. Advantages, disadvantages, and examples of studies using these methods are summarized in Table 1. Revealed preference methods involve examining behavior to expose consumer preferences. Two revealed preference approaches applied to restoration are the hedonic pricing method and travel cost method. The hedonic method is used to value environmental amenities that affect the price of residential properties. It is particularly appropriate for evaluating projects in urban settings. Examining changes in property prices can reveal the types of ecological characteristics preferred when purchasing property. For example, Bark et al. (2009) related vegetation characteristics to habitat resulting from proposed riparian restoration projects and found that homebuyers preferred properties with high quality habitat. Additionally, the hedonic method has been applied to examine the impact of new environmental rules on property values. Bin et al. (2009) looked at rules requiring riparian buffers on residential properties and found that the buffer rule did not affect property prices. From a planning perspective, understanding which environmental amenities are most important to homebuyers can focus restoration efforts and inform land use policy within residential areas. The hedonic method is relatively straightforward to apply because it is based on actual market transactions that include personal preferences as part of property value. This approach is not appropriate for use on agricultural or working forest lands where value depends on an income stream from the production of market goods.

The travel cost method is predominantly used to estimate direct use values associated with recreation sites. Visitor time and expenditures to visit a particular site are used to represent the value of that site. Studies using this method have examined how recreational users react to forest management decisions and have compared impacts of restorative prescribed burns to catastrophic fire (Loomis et al. 2001; Hesseln et al. 2003; Hesseln et al. 2004). Findings from these studies indicate

Table 1. Advantages, disadvantages, and examples using nonmarket estimation methods.

Estimation Method	*Advantages*	*Disadvantages*	*Examples Included in Review*
Hedonic method	Useful for observing actual consumer behavior. Can be used to assess potential impacts to property values, preferences by property owners for extent and level of restoration. Can use publicly available data like tax records, GIS data.	Represents property owners only; others with standing not represented. Requires strong assumptions about most significant environmental values.	Bark et al. (2009), Bin et al. (2009)
Travel cost method	Useful for observing actual or potential behavior. Can be used to understand restoration impact to recreational users. Can differentiate between different types of users.	Limited scope, potential sampling bias, issues of substitution among sites. Requires assumptions about identifying value of personal time. Requires survey.	Loomis et al. (2001), Hesseln et al. (2003, 2004)
Contingent valuation	Can provide estimates for nonmarket and indirect use values. Can differentiate between different types of users.	Some individuals may resent the monetization of benefits, or report amounts in excess of ability to pay. Requires survey.	Weber and Stewart (2009), Holmes et al. (2004), Jenkins et al. (2002), Kline et al. (2000)
Experimental choice	Can provide estimates for nonmarket and indirect use values. Multiple levels of restoration can be evaluated at different cost levels. Responses can be evaluated as ranking of preferences. Can differentiate between different types of users.	Some individuals may refuse the monetization of benefits, or report amounts in excess of ability to pay. Requires survey.	Weber and Stewart (2009), Loomis et al. (2005)
Benefit transfer	Can be inexpensive and quick to implement.	Must be carefully executed or results will be misrepresentative.	Loomis et al. (2005)
Cost methods	If cost data is available, can be quite simple to estimate.	Do not accurately reflect demand as they equate values with costs expended.	McPherson (2007), Snider et al. (2006)

that forest users do not respond uniformly among user group type (cyclists, hikers, etc.). Loomis et al. (2001) found that hikers were not impacted by catastrophic natural fires, but that cyclists were sensitive to this type of fire. In contrast, Hesseln et al. (2003) found that recreational users may increase their visits after a prescribed fire. Perhaps not surprisingly, Loomis et al. (2001) found that the number of years since fire had an impact on user demand. Hesseln et al. (2003) acknowledged that their study lacked an examination of ecological values associated with fire and did not assess whether or not awareness of such values would impact use.

Stated preference methods use surveys that ask participants' WTP for environmental improvements and are one of the only ways to measure indirect use values. In the contingent valuation method, individuals are asked how much they would be willing to pay for a defined policy or project. Jenkins et al. (2002) used these types of surveys to distinguish between recreation user group preferences for forest protection. Referendum methods ask about willingness to vote for a particular restoration program. Loomis et al. (2000) presented a restoration program funded by increasing resident water bills; they found that respondents would approve such an initiative and were willing to pay for ecosystem restoration. Experimental choice methods ask individuals to choose from a set of alternatives representing particular levels of attributes (Carson et al. 1994). Results can be expressed as a ranking of preferences. Weber and Stewart (2009) used both experimental choice and contingent valuation to estimate public values for four restoration categories in a riparian area along the Middle Rio Grande. Respondents valued restoration of native tree species most highly, followed by reducing vegetation density, and were also willing to pay significantly for wildlife and natural river processes. Despite the many criticisms of these methods, including the inconsistency of choices, implausible responses to hypothetical questions, and absence of meaningful budget constraints, they are used widely, including by federal agencies (Diamond & Hausman 1994).

The benefit transfer method involves taking values derived from one geographic location and applying them to another. Benefit transfer is often used when time or budgets constraints prohibit an original valuation study, yet some measure of benefits is needed. It has been used by regulatory agencies because it can be easy and fast to implement (Iovanna & Griffiths 2006). Loomis et al. (2005) combined benefit transfer with contingent valuation to examine WTP for forest fuel reductions and the transferability of WTP among three states and found that levels were similar among the three states. Because benefits and their values differ greatly across locations, this is usually considered a weaker approach to methods that involve collecting primary data from specific sites or projects (Rosenberger & Loomis 2001).

Nonmarket methods can be combined with market approaches to account for a larger set of values. These approaches are a good choice when projects include significant use and non-use values. We found surprisingly few examples of combined approaches. To assess the profitability of timber production from restored longleaf pine (*Pinus palustris*) ecosystems in the U.S. South, Alavalapati et al. (2002) combined nonmarket benefits such as carbon sequestration and endangered species habitat protection with long-term projections for income from future harvests. They found that a subsidy was required to make longleaf pine financially competitive. Kline et al. (2000) looked at impacts of Oregon's Coastal Salmon Restoration Initiative on nonindustrial forest owners and WTA a tax incentive in exchange for foregoing harvest in riparian buffers. WTA varied by landowner type (production, multi-objective, or recreationalist) and by the incentive amount offered.

Cost-based methods use the cost of restoration or replacement as a proxy for the value of environmental services. Replacement costs are used commonly to assess the value of street trees. McPherson (2007) used tree size, condition, and location to assess the replacement cost of a green ash (*Fraxinus pennsylvanica*) in Fort Collins, Colorado. He then compared the replacement cost with a benefits-based approach using estimates for energy savings, carbon sequestration, air quality improvements, and stormwater runoff reductions. The benefits-based approach yielded a much lower tree value at year 40 than the replacement cost approach. Avoided cost methods equate value with costs avoided by not incurring damage in the first place. These methods have been used to quantify the value of preventing wildfire using fuel treatments to reduce fire risk. Snider et al. (2006) compared the costs of restoration-based fuel treatments to the cost of fire suppression and rehabilitation in Arizona and New Mexico and found that the avoided costs associated with treatment had large positive net present values. Although cost-based methods may be relatively quick and easy to implement, practitioners are cautioned against relying solely on these methods to make decisions because costs fail to reflect demand for restoration and therefore say nothing about the efficiency of an investment.

Estimating Restoration Costs

Theoretically, any organization engaged in restoration work should be able to inventory total direct expenditures. Generally, direct costs fall into two categories: construction costs, and operation and maintenance costs (Guinon 1989; Zentner et al. 2003). These two broad categories fail to account for the hidden costs of restoration, including but not limited to planning, permitting, overhead, facilities, volunteer time, and monitoring (Guinon 1989; Zentner et al. 2003). Nor do they account for opportunity costs, such as the value of unsold timber or other foregone revenue. In addition, restoration can lead to unintended consequences that cost estimates fail to capture, such as when the introduction of carnivorous wildlife results in predation losses to local ranchers. We found that costs are rarely discussed or analyzed in the restoration literature. Holl and Howarth (2000) explained that a large share of restoration work is performed by consultants who publish infrequently or view cost data as proprietary. Restoration costs are often combined with other capital improvements and are not easily separable (A. Erickson 2010, Cascade Land Conservancy, Seattle, WA, personal communication). Even databases

Table 2. Advantages, disadvantages, and examples using decision-analysis frameworks.

Framework	*Advantages*	*Disadvantages*	*Examples Included in Review; Suggested Further Reading*
Benefit-cost analysis	Allows for comparison of costs to benefits. Comparisons can be made based on different levels of restoration desired.	Although BCA should present data and analysis clearly to ensure transparency, decision-making process still subject to political process. Difficulty in identifying what to discount and by how much, and how to weight and distribute costs and benefits.	Holmes et al. (2004), Zerbe et al. (2010)
Cost-effectiveness analysis	Allows for comparative evaluation of projects with similar goals. Monetization of values not necessary.	Does not allow for comparison of different levels of restoration. Difficulty in identifying distribution of costs and benefits.	Pinjuv et al. (2001), USACE (2003)
Multi-criteria decision analysis	Can include multiple types of objectives (quantitative and qualitative). Monetization of values not necessary.	Requires extensive data. Not as widely used as BCA or CEA.	Wainger et al. (2010), Kiker et al. (2005)

intended to serve as information clearinghouses for restoration projects (Jenkinson et al. 2006) lack treatment cost data.

Decision-Analysis Frameworks

There are several frameworks available that organize information on benefits and costs to provide a means of comparing projects (Table 2). These methods are useful because the comparison of expected project benefits and costs across a range of treatment options can inform the design or assessment process. Although decisions about ecological restoration are not based solely on economic factors, the result, hopefully, is that restoration resources are considered using frameworks that are transparent and can withstand external scrutiny.

One basic tool is traditional financial analysis, whereby direct costs are compared against revenues generated through restoration. Lynch (2001) reported costs and revenues from a forest restoration and fuels removal project that produced a modest amount of merchantable timber. Results suggested that although projects may achieve ecological objectives, failure to yield profits discourages investment in technology. This type of assessment, although limited to market benefits, can provide an easy and quick clarification of short-term financial viability and can account for time through use of discount rate.

Benefit-cost analysis (BCA) calculates total expected benefits and costs of a project over time and discounts them to present value, with the goal of identifying the project with the greatest net benefit. BCA can account for both market and nonmarket values after applying methods reviewed above. One advantage is that BCA provides a framework for achieving the highest level of restoration desirable (Kline 2004). Holmes et al. (2004) calculated costs from 35 riparian restoration projects and estimated the benefits of five ecological indicators. They calculated annual benefits over a 10-year period and found that both partial and full restoration yielded positive benefit/cost ratios. Values associated with full restoration generated a significantly higher benefit/cost ratio over partial restoration (15.65 vs. 3.33), indicating the scale of restoration had an effect on the magnitude of benefits.

Although economic theory supports the use of BCA to measure the potential gains from trade, BCA has been criticized on philosophical, technical, and political grounds (Table 2). Persistent criticisms of BCA stem from the lack of concern for equity and distribution (Zerbe et al. 2010). BCA is underpinned by the idea that an outcome is preferable if aggregate benefits exceed aggregate losses and that the winners of any outcome could compensate the losers; this is also known as a potential Pareto improvement. However, marginal utility of income varies across social demographics. This means that some groups are more sensitive to changes in income. Therefore, distributional weights are critical when policies result in an unequal stream of net benefits between groups. In these cases, BCA could be most informative in identifying potential sources of inequities. Although BCA is required for many major federal programs, BCA's role in environmental management is highly contested and has been the subject of prominent legal challenges (Hsu & Loomis 2002). In turn, this has led to the design of alternative frameworks.

One such method is cost-effectiveness analysis (CEA) (USACE 2003). CEA compares the relative costs and benefits of multiple means to meet the same restoration goal by identifying cost differentials associated with different approaches. The option that meets the objective for the least cost is selected. Pinjuv et al. (2001) used CEA to compare methods to restore ponderosa pine forests in Arizona. They developed effectiveness scores using indicators representing residual stand damage, soil compaction, and fuel loading which they compared against the cost of hand, cut-to-length, and whole tree harvesting methods in three different types of stands. They found that costs and impacts differed across stands so the preferred alternative would depend on the acceptable level of damage versus cost.

Multi-criteria decision analysis (MCDA) employs techniques using performance scores calculated from either qualitative or quantitative criteria and does not require assigning monetary values to environmental services. MCDA is regarded as effective at incorporating tradeoffs and perspectives from multiple stakeholders to optimize policy alternatives (Turner et al. 2000; Kiker et al. 2005). Wainger et al. (2010) combined multi-objective optimization, cost-effectiveness, and spatial analysis techniques to develop a decision-support framework for controlling nonnative invasive grass on western rangelands. They assigned indicators (instead of monetary values) to assess the relative economic benefits of four ecosystem services: recreational hunting, forage production, property protection, and incorporated existence values for the sage-grouse. By adjusting levels of these benefits based upon the likelihood of restoration success, their approach generated a higher level of the bundle of the four ecosystem services than a management strategy of selecting restoration sites that produce high levels of a single ecosystem service. This study demonstrates the effectiveness of using indicators, combined with information on the relative value and costs of restoration, in developing tradeoff assessment tools.

Discussion

Not all estimation methods are applicable in all cases. Hedonic pricing methods are best suited to urban areas and only when the interests of property owners are relevant. The travel cost method is useful when restoration will impact visits to a recreation site. Stated preference methods are useful when non-use values are involved, such as knowing that a particular wetland will be restored; experimental choice methods may be preferred over contingent valuation because they allow for the ranking of preferences and the expression of relative preferences rather than requiring discrete monetary values. Decision-analysis frameworks can incorporate a wider array of restoration benefits, as well as costs. BCA is not limited to large projects, but practitioners may encounter challenges during implementation, such as selecting and applying a defendable discount rate and deciding how to weight and distribute benefits and costs. CEA can provide a framework for avoiding some of these challenges by comparing relative costs of different methods that can be applied to achieve the same outcome. Newer methods like MCDA have evolved to allow analysts to rank or prioritize projects and goals without the monetization of benefits.

In our examination of the restoration literature, we found other issues that should be considered when applying these methods. The scale of analysis and location of the study area can create challenges; methods that rely on measuring preferences are contextual and have limited potential for scaling-up to make inferences about larger populations (Stevens et al. 1991; Vatn & Bromley 1994). In addition, individuals must exhibit a measurable response to changes in the level of an ecosystem service. If individuals cannot differentiate between subtle changes in the landscape, values estimated through nonmarket techniques may be inaccurate. Last, valuation efforts have focused primarily on the benefits of restoration, with inadequate attention paid to defining, reporting, and accounting for costs. Even direct costs, which should be comparatively easy to account for, are rarely reported. Sharing such information is widely touted as a means of improving project planning and evaluation, but as we found, still lacking. For these data to inform planning, as has been suggested (Jenkinson et al. 2006), organizations must also be willing to share them, and clearinghouses must make them available. We suggest that organizations could benefit greatly through standardizing data gathering and improving data sharing. One way to standardize the gathering and sharing of such information is through the development of protocols for gathering and reporting the direct costs of restoration activities.

Our goal in this article is to show how applying techniques from economics can facilitate decision analysis, with the goal of improving the effectiveness of restoration projects. We described how market and nonmarket based approaches have been used to estimate the costs, benefits, and values associated with restoration. These techniques begin to incorporate social values to better approximate the TEV of improving the environment. Estimating the TEV of ecological restoration is difficult at best and impossible in many cases (Kline 2004). We recognize that practitioners may not have the resources to utilize these methods without technical assistance. It is not practical for all project planners and evaluators to implement the more complicated methodologies; instead we suggest that they consider, as thoroughly as possible, all costs and benefits of a project. Our hope is that by raising awareness of the role of economics, ecologists will consider collaborating with economists, especially during the early phases of project planning and design.

Implications for Practice

- Consider integrating economic techniques early when planning restoration projects.
- Not all methods require monetary estimates. Indicators and ranking methods incorporate intrinsic restoration values without monetizing benefits.
- Decision-analysis frameworks can help frame economic and ecological objectives. CEA allows practitioners lacking resources to assess the least-cost way of achieving ecological objectives. MCDA incorporates the widest set of values but may be difficult to implement.
- Record costs in a systematic way and make data available in order to improve project planning and evaluation.

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Appendix. Source and number of articles retrieved for review.

Journal or Type of Source	*Number of Articles Retrieved*
Institutional publications (U.S. Forest Service, University Research Entities)	31
Ecological Economics	15
Restoration Ecology	9
Journal of Forest Economics	6
Land Economics	6
Journal of Environmental Management	5
American Journal of Agricultural Economics	5
Conservation Biology	4
Biological Conservation	4
Ecological Restoration	4
Journal of Forestry	4
Journal of Agricultural and Resource Economics	2
Journal of Forest Policy and Economics	1
Arboriculture and Urban Forestry	1
Total	97