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Assessing natural resource damages using environmental annuities

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Abstract

Although research methods exist to place economic values on lost wetland service flows, in many circumstances the cost of conducting such research exceeds the expected value of damages. In some cases sufficient time may not be available to undertake primary research. In addition, the existing wetland valuation research base is often inadequate to support defensible benefits transfer. As an alternative to more traditional valuation techniques, we propose a simplified approach based on environmental annuities. The principal assumption behind this approach is that the public can be compensated for past losses in environmental services through the provision of additional services of the same type in the future. An application of this approach as the basis of a recent natural resource damage claim is described.

Keywords: Annuity; Damage assessment; Wetland value

1. Introduction

Growing concern with environmental damages led to the passage of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980. Under CERCLA, public agencies, acting as trustees on behalf of the public, can claim economic damages resulting from injuries to natural resources associated with the release of oil and other hazardous substances to the environment. While a limited number of damage claims have been brought to-date under this statute, the most notable being those claims resulting from the *Exxon Valdez* oil spill, a much larger number of claims for a wide range of damages to natural resources are expected in the future (Breen, 1989). In addition, other federal and state statutes, including the 1990 Oil Pollution Act (OPA), allow for the recovery of damages resulting from environmental injuries. Damage claims under these statutes can extend beyond resource replacement or restoration to include compensation for losses in environmental services from the time of release through full resource restoration or replacement. Such interim losses can include both use values (e.g., lost recreational beach days) and non-use values (e.g.,

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existence values). Thus, the development and application of natural resource valuation techniques for the purpose of damage assessment continues to receive attention (Kopp and Smith, 1989).

While a variety of primary research methods are available to estimate the economic damages resulting from environmental contamination (Cross, 1989), these methods will not be applicable in all cases. In some cases, the cost of applying these methods and of collecting the required physical impacts data in a manner that will stand up to the scrutiny encountered in the course of a contested damage claim may be large relative to the expected magnitude of damages. In addition, sufficient time may not be available to plan for and complete detailed, case-specific research. For example, a state-of-the-art contingent valuation study, even for a relatively simple damage claim, can cost hundreds of thousands of dollars and take over a year to complete.

While benefits transfer techniques may be applicable under such circumstances, a sufficient research base is not always available to support such transfers. For example, many oil spills and other hazardous material releases result in a reduction or loss in the flow of services from tidal marshes or freshwater wetland. As noted in Batie and Shabman (1982), however, few conceptually valid estimates of the economic value of wetland exist. Thus, available studies may be insufficient to support defensible benefits transfer. In addition, the existing research base addresses only a limited number of service flows provided by these systems. For example, Farber and Costanza (1987) considered the commercial fisheries, recreation, and storm protection value of wetland in southern Louisiana, but ignored the potentially significant non-use values of these systems. Even in cases where values are required for only a given category of service flow (e.g., the lost recreational value of wetland), these values can vary significantly by location and wetland type. For example, while Farber and Costanza (1987) and Bergstrom et al. (1990) found the annual recreational value of wetland in southern Louisiana to be between \$6 (1983\$) and \$8 (1987\$) per acre, respectively, Thibodeau and Ostro (1981) estimated the total recreational value of an acre of wetland in eastern Massachusetts to be as high as \$187 (1977\$). These differences result not only from differences in the primary use of these systems by recreationalists, but from the uncertainty inherent in the methods used to generate these estimates. Clearly, alternative, less data- and less research-intensive techniques for wetland valuation would be useful.

In this paper, we describe the theoretical basis of a simplified approach that provides one alternative to conventional economic damage assessment. We then describe its application to a damage claim brought by the federal government in a recent court proceeding. This claim involved the interim loss of wetland services as a result of the filling of wetland with a hazardous substance. This example is significant in that it represents the first damage claim under CERCLA heard in the course of a bankruptcy proceeding, as well as the first damage claim brought by a federal trustee to be heard by a court. This paper concludes with a review of the implications of applying this methodology in future damage assessment efforts.

2. Theoretical model

Natural resources provide a variety of environmental services. For example, freshwater wetland can act as a conduit for floodwaters, provide water storage capacity during rainfall events, contribute to improved water quality, and provide habitat for fish, shellfish, waterfowl, and mammals. The benefits of such services may accrue on-site (e.g., wildlife viewing) or off-site (e.g., protection of downstream communities from floods and non-use values) (Scodari, 1990). Conceptually, the value of a given acre of wetland can be expressed as:

$$N = f(S_1, S_2, S_3, \ldots, S_x), \quad (1)$$

where N equals the total economic value of the wetland, and S a vector of the service flows provided by the wetland. The total value of these service flows will vary between sites since locations of wetland relative to human populations and the type and quantity of each S_x will vary.

The quantity and monetary value of these service flows, however, are often unknown and difficult to measure. For example, the value of an acre of freshwater wetland for flood control will depend on the physical properties and location of the wetland. These properties would include such factors as the water retention capacity of the site and the frequency and severity of flooding events. For some categories of service flow, such as the marginal contribution of a site to the abundance of an endangered species, the physical and biological relationships may not be well understood. In some cases the cost of estimating the value of services provided by a wetland system will be substantial, and even if such an effort is undertaken, uncertainty about the resultant estimates may be unacceptable for litigation purposes.

Our proposed model is intended to avoid these data limitations, while defining a way to compensate the public for lost use and non-use values when releases of oil and toxics have reduced wetland services. Let:

$$D = \sum_{t=d}^{R} D_t$$

$$= N \sum_{t=d}^{R} W_t (1+i)^{(T-t)}$$

$$= N * W, \qquad (2)$$

where:

D_t = the present value in year T of damages incurred by the public in year t as a result of the loss of W_t acres of wetland;

D = the present value in year T of damages incurred by the public as a result of the loss of W_t acres of wetland in years $t = d$ to R;

W_t = number of acres of wetland lost in year t;

N = total economic value of an acre of wetland, as defined in Eq. 1;

W = present value in year T of wetland services lost, years $t = d$ to R, expressed in wetland acre years;

d = year in which damage first occurred;

T = current year;

R = year wetland restoration is completed; and

i = the real interest rate.

It is assumed that damages occur until year R, at which point restoration or natural recovery is completely successful (i.e., $t = 1,\ldots,n$). Obviously, permanent loss is a possibility, in which case $R = \infty$ and the capitalization formula would apply to the permanently lost wetland. Similarly, in some instances restoration will occur slowly over time as the replacement wetland becomes fully functional. For example, while restoration may not be completed until year R, the replacement wetland may provide some of the services provided by the original wetland prior to year R. In these instances it may be desirable to attempt to account for the extent of recovery over time (King, 1991, 1992).

If N were known, then damages D could be assessed in monetary units. We are concerned, however, with cases in which N is unknown. Thus, we ask the question: how many acres of newly created wetland producing N dollars in services per-acre per-year in perpetuity would be required to produce the equivalent of D? If we let X be the number of newly created wetland acres required to fully compensate the public for past losses, and r equal the number of years until full recovery (i.e., $R - T$), then

$$N * W = \left[\frac{N * X}{i}\right]\left[(1+i)^{-r}\right], \qquad (3)$$

which can be solved for X. The first term on the right hand side is simply the capitalized value of X acres of wetland multiplied by N dollars per-acre per-year in perpetuity, while the second term converts this capitalized value to a present value. Since N, the unknown economic value of an acre of wetland services, appears on both sides of Eq. 3, it cancels out and we are left with X, which is interpreted as a measure of damages, expressed as the number of acres of newly created wetland required to compensate the public rather than the usual dollar metric. Under the assumption that N is constant, X acres of wetland, created and fully functioning r years in the future, will provide an "annuity" of environmental services in perpetuity that is sufficient in present value terms to equal the present value of damages. An annuity is an asset that pays a fixed sum each year for a specified number of years. In practice, the magnitude of the damage claim in such a case would be equal to the cost of creating or restoring X acres of wetland services. Appropriate methods that can be used to estimate the cost of creating or restoring wetland, and issues that are commonly encountered in developing such estimates are discussed in Shabman and Batie (1987).

There are two principal assumptions inherent in this approach. The first is that the value of wetland services is constant through time. It could be argued that the marginal value of wetland has been increasing through time, since the total acreage of wetland has declined and since public concern for wetland has increased. Alternatively, it could be argued that the marginal value of wetland will decline in the future, as the cost of creating new wetland declines, or as the cost of providing substitutes for the services provided by wetland, such as wastewater treatment, declines through technological progress. In addition, as more wetland is acquired and preserved by public agencies, and as state and federal wetland law reduces the rate of loss of wetland acreage, the marginal value of wetland acreage could decline. Constant N may thus be considered expedient at least until long-term trends in wetland values can be determined.

The second principal assumption is that the cost of creating new wetland does not significantly over- or understate the true damages resulting from wetland loss. That is, under CERCLA and OPA, the polluter must provide monetary compensation to the public for interim lost services. Clearly, replacement costs are a poor cousin to theoretically correct welfare-based measures of economic damage. For example, the value of all services provided by an acre of wetland could be significantly less than the cost of creating new wetland. In such cases the polluter may argue that this approach overstates the true damages. It is interesting to note that the court in Ohio versus The U.S. Department of Interior held that compensable damages should include the cost of restoring, replacing, or acquiring the equivalent of lost resources as long as the cost of such actions is not "grossly disproportionate" to the value of services provided by such resources (State of Ohio v. U.S. Department of Interior, 1989). Thus, even in cases in which the cost of creating new wetland exceeds the expected value of services lost, the courts may support such claims.

Now let us consider the case in which the injured wetland continues to provide some level of environmental service. For example, a wetland that is illegally filled may continue to provide environmental services as productive upland. In this case, damages would be expressed as:

$$D = \left[N_{\text{wetland}} - N_{\text{upland}}\right] \sum_{t=d}^{R} W_t (1+i)^{(T-t)}$$
$$= \left[N_{\text{wetland}} - N_{\text{upland}}\right] * W, \tag{4}$$

where:

N_{wetland} = value of services provided by undamaged wetland; and

N_{upland} = value of services provided by wetland converted to productive upland.

In this case damages equal the product of the present value of acre-years of wetland services lost and the difference in the value of services provided by the site as wetland as opposed to upland. Since new wetland is generally created through the conversion of upland to wetland, we can modify Eq. 3 to:

$$\left(N_{\text{wetland}} - N'_{\text{upland}}\right) * W$$
$$= \left[\frac{\left(N_{\text{wetland}} - N_{\text{upland}}\right) * X}{i}\right]\left[(1+i)^{-r}\right], \tag{5}$$

where:

N'_{upland} = value of productive upland to be converted to wetland.

As is shown, if we assume that the value of ecological service flows provided by the filled wetland (N_{upland}) is equal to the value of the upland site prior to conversion to wetland (N'_{upland}), then these two terms will cancel. If the filled site is actually more valuable as upland than the remediation site ($N_{\text{upland}} > N'_{\text{upland}}$), then the public will be over-compensated, ceteris parabus. Similarly, if the value of the filled site as upland is limited ($N_{\text{upland}} < N'_{\text{upland}}$), the public may not be fully compensated for environmental service flow losses through the creation of new wetland from upland.

3. A case study

The Great Swamp National Wildlife Refuge is located in northern New Jersey, approximately 25 miles from New York City and 15 miles from Newark, New Jersey. This 7000-acre refuge was founded in the early 1960s as a result of concerns over development of the Great Swamp, in particular, the proposed use of the Swamp as the site for an international airport. The Great Swamp National Wildlife Refuge provides an important link in the refuge system that supports waterfowl and other migratory birds of the Atlantic flyway, and serves as a habitat for local wildlife. In addition, the Refuge is a well-known and heavily visited recreational site.

Two dumps containing asbestos and other hazardous substances are located within the Great Swamp National Wildlife Refuge. In 1991 the U.S. Fish and Wildlife Service (the Service) filed a natural resource damage claim against the firm that generated and disposed of these wastes. This claim alleged that, as a result of asbestos disposal, the services that would normally have been provided by the dump sites had been interrupted. Based on interpretation of historical aerial photographs, it was determined that the dump sites were wetland prior to being filled with asbestos wastes. Our assignment was to estimate the economic damages associated with the loss of these wetland services from the initiation of disposal operations through site remediation (i.e., interim lost use and non-use damages). Since the Service brought this claim as part of a bankruptcy proceeding, limited time was available to complete this research.

While there is evidence that asbestos wastes were used as fill at this site as early as 1962, definitive data on the areal extent of this fill operation are not available prior to 1968, the year in which the Service purchased the property on which the dump sites are located. These data indicate that 5.58 acres of wetland were lost as a result of the fill operation. Given the large volume of asbestos wastes at the site, the Service has determined that the most applicable alternative for this site is to cap the wastes in place. As a result, this wetland acreage will be lost in perpetuity. In order to compensate for future losses (wetland services that would have been provided in the future in the absence of site contamination) resulting from site capping and closure, the Service has claimed the cost of creating seven new acres of wetland (the acreage of the capped site). In the absence of a more precise estimate, we assumed that this new wetland acreage would be created and fully functional by January 1 of 1998 (i.e., $r = 5$). Note that this new wetland acreage is required to fully compensate the public for losses in wetland services in the future, while our analysis was intended to provide a measure of economic losses suffered in the past. Thus, interim damages were assumed to have begun in 1968 and to end in 1998.

Using the framework described above, we calculated the number of acres of new wetland required to compensate the public for interim losses. Since 1968, W_t has equaled 5.58 acres. Assuming that the use and non-use values of the service flows from this acreage equal N dollars per-acre per-year, that N is constant over time, and that the real interest rate is 3%, damages can be calculated as:

$$D = \sum_{t=1968}^{1997} D_t = N * 5.58 \text{ acres} * (1 + 0.03)^{(1992-t)}.$$

Solving this equation we find that 228 acre-years of wetland services, expressed in present value terms as of January 1, 1993, will have been lost at the Great Swamp National Wildlife Refuge by 1998. We then apply Eq. 3 to estimate the number of acres of new wetland required to compensate the public for these interim losses. Thus,

$$228 * N = \left[\frac{N * X}{0.03}\right]\left[(1 + 0.03)^{-5}\right].$$

Since N cancels, we find that X equals 7.96 acres, the number of acres of new wetland sufficient to compensate for interim damages. More formally, 7.96 acres of new wetland would compensate the public for the services that would have been produced by the 5.58 acres of wetland lost from 1968 to 1997 as a result of asbestos disposal at the Great Swamp, plus accumulated interest on these services. Note that this acreage is in addition to the seven acres claimed by the Service to compensate the public for future losses resulting from capping and closing the site.

The defendants in this case argued that this approach failed to take into account the fact that the site, as a dump, still provided positive upland service flows. As described above, since the proposed remedy in this case involved the creation of new wetland from upland, a full accounting of all environmental services would require consideration of the economic value of upland services lost at the site of the replacement wetland. To simplify this analysis, we assumed that the loss in upland services at the new site fully offset any positive upland benefits provided by the dump site. This assumption was supported by the fact that the dump site, as upland, provided limited environmental services as compared to available replacement sites.

4. Summary and conclusions

Given the high cost of primary research, uncertainty inherent in available methodologies, the lack of a sufficient literature base to support benefits transfer, and the need to address damage estimation quickly and at low cost, we propose an environmental annuities-based approach to damage assessment. This approach is based on the assumption that the public can be compensated for past losses in environmental services through the provision of additional services of the same type in the future.

This approach is particularly attractive when viewed in the legislative context of CERCLA and OPA, the two primary natural resource damage laws, in which Congress explicitly made restoration of environmental services the primary goal. The legal viability of this approach remains undetermined. In the case of the asbestos dumps in the Great Swamp National Wildlife Refuge, the bankruptcy court ruling from the bench found that the Service had "failed to establish a reduction in wetland services" under CERCLA (Felsenthal, 1992, p. 16). As a result, the judge in this case did not rule on the use of the environmental annuity approach. While this approach is being used by the U.S. Department of Interior and the National Oceanic and Atmospheric Administration in other cases, these cases have not yet come to trial.

There is no obvious reason why application of this approach should be limited to cases involving wetland service flow interruption. For example, an oil spill that results in an extended beach closure could be compensated for though actions to increase the number of beach user-days available in the future. This approach may be desirable in cases in which the cost of estimating the value of lost beach-use days is of the same order-of-magnitude as the expected damages. Such a solution is also politically advantageous, in that those individuals who suffered losses as a result of the hazardous substance release event are most likely to benefit from the damage award.

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