Natural Resource Damage Assessment: The Role of Resource Restoration

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ABSTRACT

To date, methods for determining compensation for spill-related natural resource damages have focused on the monetary value of resources damaged by a spill or scientific analyses of resource restoration. This paper suggests an alternative approach that integrates legal concepts of public trust, economic definitions of compensation, and scientific approaches to restoration. The approach is based on a definition of restoration as resource-based compensation—a remedy for damages wherein alternative restoration actions are identified that provide "equally valued" resources as those lost due to the spill. This provides an explicit balancing between the benefits obtained from restoration and losses due to the spill to assure that the public is made whole. The least costly alternative that makes the public whole is selected as the cost effective alternative.

INTRODUCTION

Restoration plays a central role in determining compensation for natural resources injured[1] by hazardous releases or oil spills under both the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)[2] and the Oil Pollution Act of 1990 (OPA).[3] In *Ohio v. United States Department of the Interior* (the *Ohio* Decision), the U.S. Court of Appeals for the District of Columbia Circuit concluded that restoration is the preferred means of compensation for spills of hazardous substances.[4] Similarly, the Oil Pollution Act explicitly states

  1. Injury is an adverse change in the chemical or physical quality or the viability of a natural resource. For example, injury includes mortality and physical impairment of biological resources (e.g., loss of reproductive capacity) or contamination of other resources (e.g., oil slicks on surface waters or shorelines, or hazardous substances in groundwater).
  2. 42 U.S.C. §§ 9601-9675 (1988).
  3. 33 U.S.C. §§ 2701-2761 (Supp. IV 1992).
  4. Ohio v. United States Dep't of the Interior, 880 F. 2d 432, 444, 459 (D.C. Cir. 1989).

that compensation for oil spills is to be based on "the cost of restoring, rehabilitating, replacing, or acquiring the equivalent of, the damaged resources," plus "the diminution in value of those natural resources pending restoration," plus "the reasonable costs of assessing those damages".[5]

This paper discusses resource restoration as a remedy for injuries to natural resources. We present a definition of restoration as resource-based compensation, whereby compensation takes the form of restored resources, and we explore new methods for determining the appropriate restoration level and for choosing among restoration programs. The methods that we suggest integrate economic concepts of compensation, legal concepts based on the public trust doctrine, and scientific approaches to restoration.

First, we describe the legal framework that provides compensation for natural resource injuries. We then describe a case study, that of the *Amazon Venture* oil spill, which will be used to provide illustrations and examples throughout the paper. Finally, we discuss some problems that arise in defining and implementing restoration, and suggest methods for addressing some of these problems.

RESTORATION UNDER CERCLA AND OPA

CERCLA NRDA Regulations and the Ohio Decision

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) provides the statutory basis for compensating the public for injuries to natural resources resulting from releases of hazardous substances. The original CERCLA Natural Resource Damage Assessment (NRDA) regulations promulgated by the Department of Interior (DOI) stated that damages were to be measured as the "lesser of" the cost of restoration and the diminution in use values for the injured resources.[6] The preamble to the regulations stated

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5. 33 U.S.C. §2706(d)(1) (Supp IV 1992).

6. Natural Resource Damage Assessments, Final Rule, 51 Fed. Reg. 27674 (1986). Following DOI, this paper uses the term "restoration" as encompassing all actions to restore, rehabilitate, replace, or acquire the equivalent of injured natural resources. "Use value" generally refers to the monetized measure of benefits that people attach to physical use of a resource, such as beach use or water drawn from public sources for residential uses. This "social value" is commonly measured by economists by the aggregate willingness to pay by members of society to avoid a specific loss of natural resources. Hence, social value is anthropocentric and reflects individuals' preferences and their ability to pay for the services provided by resources. Serious measurement problems arise in many cases, especially when the services lost are not traded in commercial markets, such as lost recreational uses, or when the services provided by the ecosystem are uncertain or unknown. Discussion of methods for measuring social values is beyond the scope of this paper. For additional information, see Water Resources Council, United States Department

that "[t]he rule takes into consideration existing common law rules for developing a theory of natural resource damages . . . . The money awarded as compensation using common law principles represents a rough measure that approximately represents the value of the thing that is lost."[7] Thus, the rule is based on the common law concept that compensation should make the injured party whole in the least costly manner.

The original regulations were immediately challenged in court by industry representatives, state governments, and environmental groups.[8] The *Ohio* Decision addressed several important issues, including the "lesser of" rule, which the court overturned.[9] This rule was challenged by state and environmental petitioners, who argued that Congress intended damages awarded to at least cover restoration of the injured resources.[10] The petitioners contended that lost-use-value would generally be less than the cost of restoration, and consequently, in most cases, damages awarded would not be sufficient to pay for restoring the injured resources.[11]

DOI defended the "lesser of" rule by arguing that Congress' intent was unclear, that DOI was given the authority to decide how damages should be measured, and that its rule should be upheld as long as it was not unreasonable or inconsistent with the statutory purpose.[12] One important issue in DOI's arguments over the "lesser of" rule was that of economic efficiency. DOI defended its rule as being economically efficient, because the public would be fully compensated either by restoring the injured resources or by receiving an amount of money equal to the lost value of the resources, and thus the "lesser of" rule would compensate the public at the lowest possible cost.[13]

However, the court ruled that an important reason for CERCLA's natural resource damage provisions was Congress' dissatisfaction with common law remedies for natural resource damages.[14] The court indicated that Congress had expressed a distinct preference for restoration over compensation for the lost value of the resources.[15] This preference was expressed in the requirement that all money collected be spent on restoration.[16] Thus, if use value is less than the restora-

of the Interior, Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, (1983); United States Department of the Interior, Type B Technical Information Document: Techniques to Measure Damages to Natural Resources (1987).

    7. 51 Fed. Reg. 27680.
    8. *Ohio*, 880 F.2d at 438.
    9. *Id*. at 441-459, 481.
    10. *Id*. at 441.
    11. *Id*.
    12. *Id*. at 442, 443.
    13. *Id*. at 443, 444, 456.
    14. Ohio v. United States Dep't of the Interior, 880 F.2d 432, 455 (D.C. Cir. 1989).
    15. *Id*. at 444, 459.
    16. *Id*. at 444-445.

tion cost, then the "lesser of" rule will not provide adequate funds to restore the resources fully, so that the public is not made whole.[17]

One possible interpretation of congressional intent is that full restoration should be carried out in each and every case, "regardless of cost and regardless of whether anybody cares," in which case DOI's argument regarding economic efficiency becomes irrelevant.[18] However, the decision to overturn the "lesser of" rule was based on the court's interpretation that the intention of Congress was not to forego efficiency, but that "Congress' refusal to view use value and restoration cost as having equal presumptive legitimacy merely recognizes that natural resources have value that is not readily measured by traditional means."[19]

In fact, the legislative history suggests that Congress intended two exceptions to restoration costs as a measure of damages: if restoration is technically infeasible, or if restoration costs are "grossly disproportionate" to the value of services foregone.[20] The court interpreted this to mean that Congress rejected the idea that the value of resources can always be accurately measured, stating that:

> [t]o say that Congress placed a thumb on the scales in favor of restoration is not to say that it forswore the goal of efficiency. 'Efficiency,' standing alone, simply means that the chosen policy will dictate the result that achieves the greatest value to society. Whether a particular choice is efficient depends on *how the various alternatives are valued* .... Congress was skeptical of the ability of human beings to measure the true 'value' of a natural resource.[21]

Thus, the emphasis on restoration unless "grossly disproportionate" was meant to capture elements of public values for resources that might otherwise be missed, such as nonuse values. This is consistent with the public trust doctrine, wherein the trustee[22] acts on behalf of the public to protect the public interest in natural resources, not on behalf of the resources themselves. However, Congress did not provide a definition of "grossly disproportionate." The court stated that "the rule might hinge on the relationship between restoration cost and

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17. *Id.*
18. W. Hanemann, *Natural Resource Damages for Oil Spills in California,* in Natural Resource Damages: Law and Economics 555, 573 (K. Ward & J. Duffield, eds., 1992).
19. Ohio v. United States Dep't of the Interior, 880 F.2d 432, 457 (D.C. Cir. 1989).
20. *Id.* at 456.
21. *Id.* at 456-57.
22. Within the context of CERCLA and OPA, trustees are members of the federal agencies, state agencies, foreign governments or Indian tribes that are specifically designated to act on behalf of the relevant public to carry out natural resource damage assessments and restoration actions. 42 U.S.C. § 9607(f)(2)(A) (1988); 33 U.S.C. §2706(a)-(b) (Supp. IV 1992).

use value (e.g., damages are limited to three-times the amount of use value)."[23]

DOI Notice of Proposed Rulemaking

The April 29, 1991 Notice of Proposed Rulemaking (NPR) issued by DOI addressed the rulings of the *Ohio* Decision.[24] In the NPR, restoration is defined generally to include "restoration, rehabilitation, replacement, and/or acquisition of equivalent" of injured natural resources, and the appropriate measure of damages is the estimated cost of the selected restoration alternative plus lost interim values for resources pending restoration.[25]

The NPR enumerates ten factors to be considered by the trustee in choosing restoration programs.[26] These are stated as *minimum factors* to be considered "among other things"[27] which "when considered together, would encompass the 'grossly disproportionate' determination suggested by the court."[28] Trustees may apply different weights to each factor, and the various restoration alternatives may balance these factors in different ways.[29] The NPR currently provides the only available guidance regarding restoration within the context of natural resource damage assessments. Yet, this guidance is not explicit or comprehensive. For example, no specific methodologies are discussed. Absence of explicit guidance will almost certainly lead to lengthy and expensive litigation in many cases.

Oil Pollution Act of 1990 (OPA)

OPA also expresses a preference for natural resource restoration over monetary compensation.[30] Natural resource damages under

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23. *Ohio*, 880 F.2d, at 443 n.7. Note that the court employs a nonstandard definition of the term "use value," which includes "passive use" or nonuse values, such as existence value—the value associated with merely knowing that a resource continues to exist.

24. 56 Fed. Reg. 19752 (1991) (to be codified in 43 C.F.R. pt. 11) (proposed Apri. 29, 1991). To date, final regulations have not been promulgated. As of July 22, 1993, DOI has reopened the period for public comment in order to obtain further comment on nonuse value and its measurement. 58 Fed. Reg. 39328 (1993).

25. 56 Fed. Reg. 19756.

26. 56 Fed. Reg. 19757. The ten factors are technical feasibility, expected costs vs. expected benefits, cost-effectiveness, results of response actions, potential for additional injury from the proposed action, natural recovery period, ability of the resource to recover with or without alternative actions, acquisition of land when restoration is not possible, potential effects on human health and safety, and consistency with federal and state laws and policies. *Id.*

27. *Id.* at 19757.

28. *Id.* at 19758.

29. *Id.* at 19757.

30. 33 U.S.C. § 2706(d)(1) (Supp. IV 1992). Note that the CERCLA NRDA regulations, when finalized, will be applicable to hazardous substance spills. Additionally, the CERCLA Natural Resource Damage Assessment regulations apply to oil spills until the

OPA are defined in the statutes as the cost of restoring, rehabilitating, replacing, or acquiring the equivalent of the injured resources, plus the diminution in value of those resources pending restoration, plus reasonable damage assessment costs.[31] As under CERCLA, sums recovered are to be retained by the trustee in a revolving trust account "for use only to reimburse or pay costs incurred by the trustee under . . . [§2706(c)] . . . with respect to the damaged resources,"[32] where subsection (c) requires the trustee to "develop and implement a plan" for restoration.[33]

This implies that the trustee is required to implement the *same* restoration plan upon which it bases its damage assessment. This is consistent with *Puerto Rico v. S.S. Zoe Colocotroni*, where compensation in the amount of the costs of purchasing lower trophic organisms from a scientific catalog was rejected because there was no intention of actually carrying out this restoration program.[34] Thus, restoration costs should be the cost of carrying out an actual program for making the public whole, not merely a means of calculating a dollar amount to be spent in some unrelated manner.

The Case of the *Amazon Venture* Oil Spill

The *Amazon Venture* oil spill will be used to provide a context to illustrate the concepts discussed in this paper.[35] The tanker *Amazon Venture* spilled approximately 500,000 gallons of No. 6 fuel oil into the lower Savannah River near Savannah, Georgia on December 4-6, 1986. Included in the impacted area is the Savannah National Wildlife Refuge, which provides a wide variety of services to wildlife, and hence ultimately provides various services[36] to the public. The refuge serves as

National Oceanic and Atmospheric Administration develops regulations under the Oil Pollution Act. A principal reason for the delay of both rules has been the controversy surrounding nonuse value and its measurement. See Natural Resource Damage Assessments Under the Oil Pollution Act of 1990, 58 Fed. Reg. 4601 (1993).

31. 33 U.S.C. § 2706(d)(1) (Supp. IV 1992).
32. *Id.* §2706(f).
33. *Id.* § 2706(c)(1)(C).
34. Puerto Rico v. Steamship Zoe Colocotroni, 628 F.2d 652, 676-77 (1st Cir. 1980).
35. The spill information provided below was obtained from J. Michel, *Natural Resource Damage Assessment of the Amazon Venture Oil Spill in* Proceedings of the 1989 Oil Spill Conference p. 303 (1989); J. Brown, *Successful Natural Resource Damage Claim for a Coastal Oil Spill in* Proceedings of the 1989 Oil Spill Conference 293 (1989); P. Biedenbender & J. Michel, *Response Strategies in a High Tidal Range Estuarine System: The Savannah River Spill in* Proceedings of the 1989 Oil Spill Conference 95 (1989).
36. Services refers to the flow of physical and biological functions performed by a resource, including services to humans. Beach use, wildlife viewing, and recreational fishing are examples of services that resources provide to people by direct use. The natural system also provides ecological services, such as habitat, that contribute to the production of wildlife and fisheries that are, in turn, used by people. In addition, some natural resources may provide services beyond those associated with physical use, such as when people enjoy reflecting upon the preservation of a unique natural environment that they do not actually visit. This final category of services is referred to as nonuse (or "passive use") services.

spawning habitat for striped bass. It also supports a variety of other anadromous fish, including American shad, hickory shad, blueback herring, shortnose sturgeon and Atlantic sturgeon.[37]

The refuge also provides habitat for an abundance of birds. Approximately 2,700 acres of former diked rice fields are managed intensively as freshwater impoundments for wintering waterfowl, wood ducks, wading birds, shorebirds and other wildlife. The refuge provides nesting habitat for wood ducks, common gallinules, purple gallinules, king rails and osprey. Many species of ducks use the refuge, including green-and blue-winged teals, ring-necked ducks, black ducks, mallards, pintails, and gadwalls.[38]

In addition, the lower Savannah river supports an important component of Savannah's recreation and tourism activities. The wildlife refuge is heavily used for waterfowl hunting, wildlife observation, commercial fishing and recreational fishing. The river also enhances aesthetic conditions within the city of Savannah, providing an important contribution to the local tourism industry. For example, the city of Savannah contains a large historic district including a restored riverfront. Several historic sites are located along the river, including Fort Jackson, which is on the National Register of Historic Places, and Fort Pulaski National Monument, which is maintained by the National Park Service.[39]

Thus, the aquatic environs in and around the lower Savannah River system provide a variety of services to the public. Some of these services, such as aesthetic qualities of the restored riverfront, are directly utilized by the public, while other services provide indirect use. These include many of the ecological functions provided by wetlands, for example, which support fish and wildlife that provide for recreational uses. Still other services may support nonuse values (or so-called "passive use" values) to the public, such as the mere knowledge that members of an endangered species continue to exist. It is the aggregate of these services that the trustee is delegated to protect on behalf of the public.

The *Amazon Venture* spill had little observable direct impact on fish and wildlife. The spill resulted in no observable fish kills, and only a small number of oiled birds were observed. However, the spill resulted in the oiling of a significant area of the wetlands that provides habitat and other services to fish and wildlife, and ultimately to the public.[40] The spill resulted in moderate to heavy oiling of 650 acres of wetlands and light oiling of an additional 690 acres of wetlands.[41]

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37. Brown, *supra* note 36, at 293-94.
38. Brown, *supra* note 36, at 293.
39. Brown, *supra* note 35 at 293.
40. Brown, *supra* note 35, at 294.
41. Michel, *supra* note 35, at 303.

In response to the spill, the State of Georgia closed the refuge to hunting and fishing for two to three weeks and closed the shell-fishing season in areas downstream of the refuge. Both federal and state trustees filed damage claims. The trustee agencies involved included the United States Fish and Wildlife Service, the National Park Service, the National Oceanic and Atmospheric Administration, the National Marine Fisheries Service and natural resource agencies from the states of Georgia and South Carolina.[42]

Amazon Venture NRDA

The *Amazon Venture* spill occurred prior to the *Ohio* Decision, but following the DOI's promulgation of the initial regulations in 1986, and is purported to be the first case to use these regulations in a natural resource damage assessment.[43] However, a full-scale damage assessment was not conducted, because an out of court settlement was expected.[44] Negotiations with the responsible party were based largely on damages to wetlands,[45] which were estimated by using three alternative approaches. These were: a use-value approach based on benefit transfer[46] for values of lost days of hunting and fishing; a use-value approach based on benefit transfer of per-acre wetland values; and a replacement cost approach applied to the 650 acres of moderately to heavily oiled wetlands. Thus, the first two approaches measure damages as lost-use value, and the third is based on restoration (or in this case, replacement) costs.[47]

The first method calculated the lost use value of the wetlands by estimating the number of lost user days for hunting and fishing, and multiplying by values per day obtained from the economics literature. This calculation only accounted for consumptive uses of the resource, and thus does not include the lost values of such nonconsumptive uses as bird watching, photography, hiking, boating, et cetera. The total lost use value for hunting and fishing in the wetlands was calculated as $275,368 to $414,024 using this method.[48]

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42. Brown, *supra* note 35, at 294.
43. Brown, *supra* note 35, at 293.
44. Brown, *supra* note 35, at 295.
45. For simplicity, we will only discuss the wetlands damage claims in detail here. There were additional categories of damages as well. These included effects on an ongoing scientific study of the impacts of harbor development on the Savannah National Wildlife Refuge, damages to fish and wildlife in the water column, and the costs of the damage assessment itself.
46. Benefit transfer refers to the practice of using "off-the-shelf" information obtained from existing studies to value lost services, rather than conducting site-specific studies to measure these values.
47. Michel, *supra* note 35, at 303-06.
48. Michel, *supra* note 35, at 304-05. There were other categories of damages in addition to wetlands. *See supra* note 45. These additional damages were estimated to be $365,518.

The second method was based on annualized values per acre for a variety of wetlands services, and thus would include consumptive (e.g. hunting) and nonconsumptive (e.g., bird viewing) uses as well as other potential services of wetlands, such as wildlife habitat, erosion control, or flood hazard reduction. This method multiplied the number of acres impacted by a range of estimated values per acre of wetlands obtained from the literature. The resulting damage estimate was calculated as $246,750 to $933,960.[49]

Both of the lost-use value methods were based on the assumption that the affected wetlands would recover naturally in a relatively short period of time. Michel notes that

> [f]ortunately, the spill and subsequent cleanup did not cause long-term damage to the root systems, and it was believed that the marshes will recover over time. Based on the opinion of various experts, the period over which services provided by wetlands will be lost was estimated to be two to three years for the areas of heavy to moderate oil contamination and six months for the lightly oiled wetlands.[50]

The final method used was the replacement cost approach, which is based on the cost of replacing the moderately and heavily oiled wetlands. The replacement cost was calculated by multiplying the 650 acres affected times the cost per acre to plant new wetlands, resulting in damage estimates of $1,300,000 to $2,730,000.[51]

However, because the moderately to heavily oiled acres were expected to recover and thus were not permanently lost, the cost of replacing all of these acres is not an appropriate measure of damages in this case. Rather, a portion of the wetland services are lost over the recovery period. Furthermore, this replacement-cost approach overlooks the services lost for the 690 lightly oiled acres.[52] The case was settled for $1.2 million, through negotiations based on the damage estimates described above, and each trustee received a portion of the settlement, based on the number of oiled wetland acres in their jurisdiction.[53]

The *Amazon Venture* damage assessment did not focus on restoration, although one of the three damage measures was based on replacement cost of wetlands. In the future, cases will emphasize restoration and thus will require different damage assessment methods. In the following sections, we discuss several important difficulties that courts face in defining and implementing restoration. We then suggest meth-

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49. Michel, *supra* note 35, at 304-05.
50. Michel, *supra* note 35, at 305.
51. Michel, *supra* note 35, at 306.
52. An alternative approach to complete replacement, replacing lost interim services with new acres of wetlands, is discussed *infra* notes 70-77 and accompanying text.
53. Brown, *supra* note 35, at 295. Georgia received $500,000, South Carolina received $240,000, and the U.S. government received $460,000. Brown, *supra* note 35, at 295.

ods for addressing some of these problems, and illustrate our ideas with examples based on the *Amazon Venture* case.

Factors That Complicate the Definition of Restoration

The evaluation of restoration alternatives is a critical component of natural resource damage assessment, given that restoration is the preferred method of compensating for damages, and that *all* compensation collected must be spent on restoration, even compensation collected for lost interim values of resources pending restoration. Although restoration appears to be a straightforward means of making the public whole, in practice restoration decisions present a complex, multidimensional challenge.

The most obvious definition of restoration is that of returning the set of injured resources to pre-spill conditions. In the *Amazon Venture* case, the strategy that focuses most directly upon restoring the exact resource that was injured involves restoring the wetlands. This simple definition of restoration is depicted in Figure 1. Injury to resources results in a diminished flow of services. In general, these may include ecological services which are indirectly valued by humans, direct human uses, and conceivably nonuse (or "passive use") services.

Here, resource services prior to the spill are at level S_0. In the *Amazon Venture* case, S_0 would represent the services of the fully functioning wetlands, as described above (e.g., habitat for fish, wildlife and birds). The spill occurs at time T_s, which results in a reduction in services to S_1. The resource recovers naturally over time, and returns to pre-spill levels at time T_n.

The figure indicates that resource restoration actions are undertaken at time T_1, so that resource recovery occurs along an accelerated path, and full recovery occurs at time T_r. Area A represents the loss in value associated with the reduction in resources over the recovery period, and area B represents the additional losses in public value that would occur under natural restoration.[54] Compensation based on restoration is thus determined as the cost of restoration plus area A, the lost interim value of the resources.[55] The question of gross proportions between restoration costs and the value of lost resources is determined by the relative magnitudes of restoration costs and the dollar value of area B, the additional losses in public value that would occur under natural restoration.

Unfortunately, defining restoration is not so simple. Efforts to restore resources are complicated by several factors, including deter-

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54. The actual calculation of these lost values would involve calculating a monetary value for the reductions in services represented by areas A and B. For a discussion of measuring social value in monetary terms, see *supra* note 6.

55. In this example, if compensation were to be based on lost value of the resources rather than restoration, the compensation collected would be the sum of the dollar values of areas A plus B.

mination of a baseline for restoration, the possibility that full restoration may not be feasible, and difficulties in identifying restoration alternatives that make the public whole.

Determining a Baseline for Restoration

The first step in determining restoration is to establish a baseline level of services, and to quantify the reduction in services caused by the spill. The actual physical measurement of injury and resulting service reductions is likely to be a difficult task in itself. For example, it is difficult to identify and measure all ecological services obtained from wetlands, and the extent to which these service flows are reduced by spill impacts. Indeed, even more readily observable impacts, such as bird mortality, can be very difficult to estimate accurately, since many birds killed by a spill sink, are disbursed, or are eaten by scavengers.[56] Measuring the extent of injury is further complicated by the fact that resources change over time in often unpredictable ways, thus confounding determination of the baseline.

Because resources change over time, resource services might have increased or decreased in the absence of a spill. For example, wetland acreage may change over time due to erosion or sea level rise, or bird populations may decline (or expand) over time due to changes in habitat that have no connection to the spill. Figure 2 depicts the baseline time paths for a resource under three scenarios. If the resource services would have declined even in the absence of the spill, the resource would follow path 1, natural recovery occurs at T_1, and the appropriate measure of losses over the recovery period is area A. If the resource is in equilibrium, so that the level of services provided is constant in the absence of the spill, the resource would follow path 2, natural recovery occurs at time T_2, and the appropriate measure of losses over the recovery period is area A+B. If the resource services would have increased in the absence of the spill, the baseline time path is path 3, natural recovery occurs at time T_3, and the appropriate measure of losses over the recovery period is area A+B+C.

The theoretically correct baseline condition to use when measuring damages is the without-spill level, rather than the pre-spill level. In case 1, returning resources to pre-spill levels is excessive, perhaps even infeasible if the ecosystem is unable to support larger stocks. Conversely, in case 3, returning stocks to pre-spill levels is inadequate. However, data may not be available to firmly establish without-spill levels of the resource. In that case, determination of the without-spill baseline, and thus the extent of injury, will not be straightforward.

56. *See, e.g.,* National Academy of Sciences, Oil in the Sea: Inputs, Fates and Effects 432 (1985).

Determination of the baseline was an issue in *Idaho v. Southern Refrigerated Transport Inc.*, where fish in the Little Salmon River were killed by a spill of agricultural fungicide from an overturned truck.[57] Idaho argued for determining the baseline number of fish using an average of fish counts for each of the three years prior to the spill.[58] However, the Court opted for measuring the pre-spill level using only the fish count data for 1987, the year of the spill, rather than the three-year average.[59]

There was an additional issue regarding the extent to which the population had recovered in the years following the spill. John Loomis and Peter Anderson, who served respectively as expert witness and lead attorney for the State of Idaho, indicate that the fishery in question was being reestablished at the time of the spill. Thus, the population would be expected to be increasing in the years following the spill. Consequently, the appropriate baseline for the population, defined by the without-spill level, would be greater than the pre-spill level, which is analogous to the baseline represented by time path 3 in Figure 2. However, this framework was argued to be speculative by the defendant, and the before-after framework was adopted by the court.[60] This is analogous to assuming a constant time path, depicted by path 2 in Figure 2.

Defining the baseline is further complicated by the stochastic, or uncertain, nature of natural resources. For example, a spill may kill 5,000 seabirds. Yet populations of these seabirds might be in the millions, and random fluctuations in the population might be orders of magnitude larger than the spill-related mortality. In this case, it may not be possible to have any confidence in measures that attempt to determine the extent to which the population has recovered from the spill-related injuries.

Finally, in order to accurately assess the baseline and extent of injury, data for both control and impacted sites are needed. The best way of collecting such data is to sample pairs of control and impacted sites both before and after the event.[61] However, it may not be practical to collect pre-spill information in many situations, such as in areas that are large and diverse, areas where spills are unpredictable, and areas where site-specific temporal changes are likely to occur. Therefore, it may often be necessary to rely only on data collected after a

57. Idaho v. Southern Refrigerated Transp. Inc., No. 88-1279, 1991 WL 22479 (D. Idaho Jan. 24, 1991). *See also* J. Loomis & P. Anderson, *Idaho v. Southern Refrigerated*, in Natural Resource Damages: Law and Economics 389 (K. Ward & J. Duffield, eds., 1992).
58. Southern Refrigerated Transp. Inc., 1991 WL 22479, at *13.
59. *Id.*
60. Loomis & Anderson, *supra* note 57, at 412.
61. T. Dean et al., *Damage Assessment in Coastal Habitats: Lessons Learned from Exxon Valdez, in* Proceedings of the 1993 International Oil Spill Conference 695 (1993).

spill has occurred. In this case, problems can arise because of unknown differences between the control and impacted sites.

Making the Public Whole

The strictest definition of restoration is the return of the precise resources that were injured to baseline conditions. However, even assuming that the baseline and extent of injury can be unambiguously determined, it often may be beyond the current state of the art to restore some resources fully. It is also possible that restoration costs will be "grossly disproportionate" to the value of the injured resources. Thus, in many cases, it may be impossible or undesirable to restore the precise resources that were injured. Under these circumstances, compensation for injured resources can take the form of creating, protecting, or enhancing substitute resources that provide "equivalent" functions or natural resource services. Under the proposed OPA NRDA regulations, the definitions of rehabilitation and replacement may be interpreted as allowing such actions.[62]

Thus, in the *Amazon Venture* case, the services provided by wetlands could be restored by focusing restoration actions on resources other than the oiled wetlands themselves. For example, alternative habitats for fish and wildlife could be provided or enhanced, thus replacing the ecological services provided by wetlands. One component of a program for enhancing a bird habitat might be to build duck boxes that would provide nesting habitat for wood ducks. Alternatively, restoration actions could focus directly on human uses, such as providing new observation towers for viewing wildlife, thus restoring or enhancing direct service flows to humans. These are illustrations of the so-called 'landscape' approach, whereby restoration efforts focus on the services provided by the overall ecosystem, rather than the specific resource that was injured. This approach is becoming recognized as a more effective means of carrying out restoration programs.

However, it is not straightforward to determine "equivalent" services, either from a scientific viewpoint, or especially from a social viewpoint. Under the public trust doctrine, the trustee acts on behalf of the public interest in natural resource amenities, not on behalf of the resource itself. Consequently, one definition of "equivalent" resources might be resources that are equally valued by society. In many cases, the public interest in natural resources can best be protected by providing equally valued resource services, rather than restoring precisely what was injured. The substitution of equally valued resources can provide a feasible and cost-effective means of achieving the goal of restoring, while conforming to the legal doctrine of public trust.

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62. 59 Fed. Reg. 1169 (1994).

Consequently, resource restoration cannot be viewed as a purely technical issue. It is not only important to select a feasible method for restoring resources but, in order to identify restoration actions that make the public whole, it is also necessary to consider public values for resources. Despite the importance of balancing ecological and social gains, to date there has been little or no coordination between natural scientists and social scientists towards establishing decisionmaking tools that balance gains of different kinds. It is particularly important to have established techniques for use in natural resource damage assessment, where lack of guidance may complicate and lengthen the negotiation process.

Restoration as a Means of "Making Whole"

The National Academy of Science report on restoration recognizes the difficulties associated with restoration planning, and states that it may be necessary to establish methods of project evaluation such that

comparisons between projects become possible, clear, and meaningful .... Thus, thorough evaluation of a restoration may become a complex, multidisciplinary process involving a great deal of data collection and necessitating that the resulting body of basically incomparable or unrelated data be reduced to manageable terms by using multiattribute decision techniques.[63]

Such methods, if based on common sense and sound theory, can serve to create a foundation for agreement between trustees and responsible parties, thus avoiding litigation and saving time and money. In contrast, the absence of established methods will impede swift and reasonable settlements. An important first step in the development of such methods is a definition of restoration as resource-based compensation that can make the public whole through the provision of "equivalent" or substitute resources.

An Economic Definition of Restoration

This section presents an economic definition of restoration. Those with economics training are strongly encouraged to read the appendix, which contains a more rigorous presentation of the following material.

Most of the natural resource damage assessment work to date by economists attempts to calculate the value of lost resource services due to a spill. The economic definition of monetary compensation for

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63. National Academy of Sciences, Restoration of Aquatic Ecosystems 65 (1992).

lost services is the amount of money that, when paid to an individual, equates the individual's level of well-being after the spill to the level of well-being in the absence of the spill and without compensation.

Thus, monetary compensation for lost services is the difference between the with-spill and without-spill levels of income needed to achieve a fixed level of well-being. For example, in the *Amazon Venture* case, one of the services, a lost day of recreational fishing, was valued at $25.[64] This implies that the average angler would be just as well off going fishing as receiving $25 but having to forgo the day of fishing.

Analogously, resource-based compensation can be defined as the amount and type of restoration that equates the individual's without-spill and with-spill levels of well-being. For example, lost wetlands services could be compensated for by enhancing wildlife habitat, thus increasing population levels to the point where the social value of the natural resource assets is maintained. This definition of restoration is consistent with the legal doctrine of public trust, where the objective of the trustee is to make the public whole in terms of maintaining the public interest in the resource assets and associated services, rather than to make the environment whole regardless of the public interest.

Typically, interim losses are defined in terms of the monetary value of lost services. However, under CERCLA and OPA, individuals *do not receive* monetary compensation for these lost services. For example, in the *Amazon Venture* case the anglers who are unable to fish are not paid the $25 per day for lost fishing days. Instead, the trustee must use the total amount of compensation received to restore resources.

There is no direct link between the value of lost services and the *cost* of restoring "equivalent" services. Thus, if anglers could not fish because of fish kills, for example, it might be possible to stock fish from hatcheries. However, there is no reason to expect the monetary value of lost services (e.g., the value of fishing) to bear any relation to the costs needed to restore lost services (e.g., the cost of hatching and stocking fish). Given that all money collected must be used to restore resource services, it is more logical to base compensation on the cost of restoring equivalent services.

The amount of compensation required to make the public whole is the least amount of money that is sufficient to provide a set of resources that maintains the social value of the natural resource assets. Consequently, depending upon how expensive restoration programs are, the value of the lost services could be far greater than, or far less than, the amount of money required to make the public whole through resource restoration. Therefore, the monetary value of lost services does not measure compensation required to make the public whole through

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64. Michel, *supra* note 36, at 305 (Table 1).

resource restoration. However, it is necessary for determining whether restoration costs are grossly disproportionate to benefits.[65]

In summary, monetary compensation is the amount of *money* that must be paid to the public in order to fully compensate them for losses suffered, i.e. to make them whole. Resource-based compensation is the amount and type of *resource services* that must be provided to the public to fully compensate them. These definitions of monetary compensation and resource compensation are both based on economic theory, and are both consistent with the legal concept of making whole. However, monetary compensation balances a payment of money for lost resources, while resource based compensation balances restored resources for lost resources. Both types of compensation involve challenging issues for implementation. However, the attempt to estimate monetary values for compensation has the additional complication of requiring people to place a dollar value on the environment.

Steps in Determining the Appropriate Level of Resource-Based Compensation

One way to determine sets of equivalent restoration actions is by using information from a contingent choice survey, where a sample of respondents are presented with alternative feasible programs for restoration, described in terms of the resource services provided and the time frame for each. These respondents could be comprised of knowledgeable experts, representatives of different interest groups or a random sample of the general public.[66] The respondents would be asked to choose the most preferred restoration programs, or to rank alternative programs. Employing standard methods of analysis,[67] such a survey could be used to determine the appropriate level and type of resource-based compensation by identifying "equally valued" resources

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65. "Grossly disproportionate" can be defined using standard techniques of cost-benefit analysis, as suggested by the court in Ohio v. United States Dep't of the Interior, 880 F.2d 432, 443 n.7 (D.C. Cir. 1989) or by some other standard, such as the 10 factors suggested by DOI in their Notice of Proposed Rulemaking, *see supra* note 26.

66. It has been argued that the public may not be sufficiently knowledgeable about resources or ecosystems to provide meaningful responses to surveys. One solution to this problem is to interview more knowledgeable respondents who serve as representatives of the various interests of the public. Another solution is to integrate technical views of experts and views of the public when developing and implementing the survey. For example, SAGE is one method that was developed as a means of accomplishing this. For information on the SAGE method, see E. Hyman & B. Stiftel, Combining Facts and Values in Environmental Impact Assessment: Theories and Techniques (1988); R. Hageman & V. Witkowski, *The SAGE Method in Endangered Species Management: Constructing Proxy Utility Functions to Measure Relative Values, in* Proceeding of the W133 Meetings (1991) (held in Monterey, California).

67. *See, e.g.,* D. McFadden, *Conditional Logit Analysis of Qualitative Choice Behavior, in* Frontiers of Econometrics (P. Zarembka, ed.,1973); J. Opaluch et al., *Evaluating Impacts from Noxious Facilities: Including Public Preferences in Current Siting Mechanisms,* 24 J. Envtl. Econ. & Mgmt. 41 (1993).

to restore, in terms of social preferences. That is, we would identify levels of alternative restoration programs that result in equal well-being for a "representative" individual. This is consistent with DOI's requirement, stated in the NPR for the CERCLA regulations, to identify a "reasonable number" of restoration alternatives.

If desired, the restoration programs could be restricted to sets of resources that are substantially "similar" to the resources injured, or they could include a broad spectrum of possible resource enhancement programs. For example, at one extreme, alternative actions for restoring a population of seabirds could be restricted to those that target the particular species and age class of seabirds that were injured. Alternatively, restoration actions could be more broadly defined to target other species of birds where restoration actions may be more feasible or less costly, or where the species are viewed as "more desirable". At the other extreme, the set of restoration alternatives could include actions that target completely different resources, such as fish or wetlands.

As noted above,[68] such broad definitions of "comparable resources" could be consistent with the definitions of rehabilitation and replacement in the proposed OPA NRDA regulations.The broader the set of restoration alternatives that is allowed, the more likely it is that we can identify a restoration program that protects the public interest at a cost that is not "grossly disproportionate" to benefits and at a cost that responsible parties find acceptable, such that compensation and restoration can proceed promptly, without the need for time consuming and expensive litigation.

This point can be illustrated by the following simple example. A spill might kill 700 seabirds, but it may not be technically feasible to restore these seabird populations, or doing so may be extremely expensive. Instead, one could find alternative resources that are viewed as "equally valuable," but that can be restored at much lower cost. For example, a survey of the public might find that a (hypothetical) program that restores 700 seabirds is "equally desirable" as a program that restores 500 waterfowl or one that restores 1,800 adult salmon. This defines alternatives that provide "equivalent" resources.

In the case of the *Amazon Venture*, natural resource damages resulted largely from impacts to wetlands. The money received in settlement was spent on a variety of projects, both related and unrelated to the actual spill injuries, but no direct restoration actions focused on wetlands. The federal government spent part of the settlement funds to continue a study of the Savannah National Wildlife Refuge for an extra year, and part of the funds to study and implement means of protecting the refuge from future spills. The State of Georgia used their portion of the settlement for five different restoration projects. These

68. *Supra* note 162 and accompanying text.

were enhancement of shellfish and finfish resources, improvements to a state fish hatchery, compiling data on, and monitoring, the Savannah River, constructing wildlife observation platforms, and enhancements to Fort Jackson. South Carolina used their funds for assessing biological resources and effects of contaminants on those resources in the lower Savannah and Wright Rivers, developing a geographical information system for coastal areas, and establishing an escrow account for future spill response.[69] No attempt was made to compare the resources actually restored with the resource damages resulting from the spill to determine whether compensation was adequate to make the public whole.

If our method had been applied to this case, the first step would be to identify feasible restoration options. The second step would be to determine the level of the restoration options that would be "equivalent" to the lost services due to the *Amazon Venture* spill. Next, one would determine which "equivalent" restoration alternative is least costly. This identifies the most cost effective restoration plan that makes the public whole. Finally, one would make sure that the cost of this plan is not grossly disproportionate to the benefit, by comparing the cost of carrying out this plan with the value of the resources restored. Thus, the benefit obtained from restoration is explicitly balanced against the services lost due to the spill. Monetary damages are then estimated as the cost of the selected restoration plan, plus lost interim values for services of the resources.

Resource-Based Compensation for Lost Interim Services

One approach to determining compensation for lost interim services pending restoration is to place a monetary value on the lost interim services, collect this money, and then determine how to best spend the money on resource enhancement activities. This is essentially what was done in the *Amazon Venture* case to compensate for lost interim services of wetlands pending natural recovery. An alternative approach is to provide resource-based compensation for lost interim services by restoring beyond the baseline level, such that the additional services compensate the public for the interim losses. This requires that we determine the resources that make the public whole and the cost of providing those resources. This approach to compensation is more consistent with the public trust doctrine, which requires that the public be made whole, and with the statutes, which require that the funds collected for lost interim services be spent on natural resources.

Using this method requires that we determine relative values of resources. However, it places less emphasis on estimating monetary values for resources, which people may often find difficult or impos-

69. Brown, *supra* note 35, at 295.

sible to express. Some measure of monetary values may still be necessary for determining when restoration costs are grossly disproportionate to benefits received. However, the use of estimated monetary values in this context may be less controversial, and lower standards of accuracy may be acceptable, than in the context of assessing monetary damages, as one only needs to determine the "gross proportion" of the values being compared.

Figure 3 depicts this measure of compensation. Here, the initial level of resource services is S_0. The spill mortality reduces the services to S_1. Enhancement actions are then taken to restore the resource services to the level $S_R > S_0$. The level of restoration, S_R, is determined so as to balance area B, which represents the services obtained from resource enhancement, with area A, which represents losses over the recovery period, after accounting for the relevant discount factor.[70] Hence, losses in resources over the period prior to recovery are redressed by gains in resources over a future time period.

We will illustrate this suggested approach using information from the *Amazon Venture*. One possible action is based on replacing the wetland services lost over the recovery period with an equal number of discounted "acre-years" of wetland services. In this case lost wetland services are compensated for with additional wetland services. Specifically, we calculate the number of wetland acres provided in perpetuity that is required to balance the temporary losses in services over the recovery period for all impacted wetlands. Our proposed approach is consistent with the post-*Ohio* preference for restoration, but extends restoration one step further by using restored resource services beyond the baseline to compensate for lost interim services of resources pending recovery.

Replacing Lost Wetland Services With "Acre-Equivalents"

For the purposes of this example, we have made several simplifying assumptions, based on the information presented in Michel and Brown.[71] We adopt all dollar figures presented by Michel. We assume that the oiled wetlands provide no services immediately following the impact, but that the services recover linearly over time. Specifically, following Michel, we assume natural recovery in six months for the

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70. Compensation can be thought of as providing a resource that is of equal value to that which was lost. A natural resource that provides a flow of services over time may be viewed as a capital asset, whose value is defined as the discounted value of its service flow. C. Clark, Mathematical Bioeconomics: The Optimal Management of Renewable Resources 68 (1976). Thus, an acre of wetlands provided today is worth more than an acre of wetlands provided a year from now because it supplies services over that period. The administratively set discount rate for natural resource damage assessments under Federal regulation is currently 10 percent. *See* 51 Fed. Reg. 27750 (1986) (citing Office of Managment and Budget, Circular A-94 Revised (Mar. 27, 1992).

71. *See* Michel, *supra* note 35: Brown, *supra* note 36.

lightly oiled wetlands, and in three years for the moderately to heavily oiled wetlands.[72] Note that the assumption of zero services following the injury may lead to overstated damages because it does not allow for the provision of partial services by injured wetlands,[73] thus overstating the services that must be restored. This is particularly pertinent for the 690 acres of lightly oiled wetlands.

First, we calculated the total discounted acre-years for the injured wetlands, assuming linear recovery. This was calculated using a ten percent discount rate, which was the rate used by the trustees in their calculation of lost wetland values.[74] Second, we determined the level of wetlands creation that was required to provide the discounted equivalent acres. This was calculated as:

$$\sum_{t=0}^{T_R} (1 + r)^{-t} W_L(t) = \sum_{t=T_R}^{\infty} (1+r)^{-t} W_G(t)$$

where t represents time in years, T_R is the time at which full recovery occurs, $W_L(t)$ is the level of loss in resource services at time t, prior to full recovery, $W_G(t)$ is the level of gains in services provided by restoration beyond the baseline and r is the discount rate. Thus, we are balancing discounted losses in wetlands services over the recovery period (represented by area A in Figure 3, above) against the discounted gains in acreage provided by restoration beyond the baseline (represented by area B in Figure 3). This provides one option for restoring lost services over the interim period, to be included among the "reasonable number" of alternatives to be compared, as required by DOI in the NPR.

It was assumed that creation of these wetland acres would occur one year following the spill. It was also assumed that it would take five years for the created wetlands to provide the full flow of services provided by mature wetlands. By using the above procedure and solving the equation for W_g, we found that a total of 153.6 acres of wetlands provided in perpetuity contributes the discounted "acre equivalent" for the temporary loss in services over the recovery period from the oiled wetlands in the Savannah River. This contrasts with the replacement cost approach presented in Michel, which is based on the complete replacement of the 650 moderately to heavily oiled acres.

The final step is to calculate the cost of creating these wetlands. Using the replacement costs presented by Michel, which ranged from

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72. Michel, *supra* note 35, at 305.
73. That is, in many cases lightly oiled wetlands will continue to provide services, although possibly at a reduced level. For example, wetlands with lightly stained vegetation may still provide detritus, which helps to support the overall food web. Similarly, wetlands with lightly stained vegetation may still provide effective removal of various pollutants from the waters.
74. Michel, *supra* note 35, at 305.

$2,000 to $4,200 per acre, the total cost would range from $307,164 to $645,045.[75] If this restoration action turned out to be the most cost effective option that makes the public whole, this amount of compensation would be collected and used to implement the restoration plan for the 153.6 acres.

Comparison of Benefits and Costs of the Plan

Using information from Michel, we can compare the cost of restoring lost interim services with the estimates of the value of the lost services. The trustee calculations of lost use values of the wetlands pending natural recovery resulted in a range of value from $246,750 to $993,960.[76] Thus, based on these estimates, the cost of restoring the lost interim services is comparable to, and bounded by, the estimates of the value of lost services, so that the benefits of restoring the lost interim services may exceed the costs.

It should be emphasized, however, that the appropriate restoration alternative is the most cost-effective solution. This example was based on a narrow definition of equivalent services, whereby lost wetland services were replaced with wetland acre-equivalents. In an actual damage assessment other restoration alternatives should be considered, and the appropriate selection is the restoration alternative that makes the public whole at least cost. For example, rather than creating additional acres of wetlands, other options could be considered, such as enhancing other wildlife habitat or enhancing public access. The primary distinction between our suggested approach and the approach more typically used, such as that applied in the *Amazon Venture* case, is that our approach includes an explicit balancing between the services obtained from restoration actions and the services lost due to the spill.

CONCLUSIONS

Traditional methods of damage assessment have tended to focus either on economic methods of estimating the value of resource services lost due to a spill or on scientific studies of resource restoration. This paper suggests an alternative approach that integrates legal concepts based on the public trust doctrine, economic methods of determining compensation, and scientific approaches to restoration.

The approach is based on a definition of restoration as resource-based compensation that provides a remedy for spill-related damages. This approach identifies alternative restoration actions that provide re-

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75. Michel, *supra* note 35, at 306.
76. Michel, *supra* note 35, at 306 (Table 2).

source services that are "equally desirable" to society as the services
lost due to the spill. Thus, there is an explicit balancing between the
benefits obtained from restoration and the losses due to the spill. In
comparison, previous methods of damage assessment make no such
explicit balancing, so that there is no attempt to determine whether
restoration actions make the public whole for injuries due to the spill.

Under our approach, the least costly restoration alternative that
makes the public whole is selected as the cost effective restoration plan.
We also suggest the idea of resource-based compensation for lost in-
terim services, whereby restored services are balanced against services
lost over the recovery period. We illustrate our methods using the *Ama-
zon Venture* oil spill as a case study.

The greater the flexibility that is allowed in defining "equiva-
lent" resources, the more likely it is that we can identify alternatives
that serve the public interest at a cost that is not "grossly dispropor-
tionate" to the value of the resource, and at a cost that is acceptable to
the responsible party. Hence, this could help to facilitate prompt, rea-
sonable and mutually agreeable solutions to natural resource damage
actions, and could help to circumvent lengthy and expensive litiga-
tion.

Appendix: A Technical Definition of Restoration

This appendix provides a technical economic definition of re-
source-based compensation, which is equivalent to the definition pro-
vided in the section entitled *An Economic Definition of Restoration.*

Monetary compensation for lost services is defined such that
utility immediately after the spill is equated to utility in the absence
of the spill (with no compensation). This is based on the usual defini-
tion of Hicksian compensation:

$$U(P,Y,NR^0) = U(P,Y+C,NR^1)$$

where $U(\bullet)$ is the utility function, P is a vector of prices, Y is income,
NR^0 is the without-spill vector of natural resource services, C is mon-
etary compensation, and NR^1 is the reduced vector of natural resource
services following the spill. Thus, monetary compensation is the dif-
ference between the with-spill and without-spill levels of income needed
to achieve the fixed level of utility. The aggregate level of compensa-
tion required can be calculated by summing over all individuals. This
is often calculated by estimating compensation required by a "repre-
sentative" or "average" individual and multiplying by the size of the
relevant population.

If restoration is defined as resource-based compensation, it can
be expressed as:

$$U(P,Y^0,NR^0) = U(P,Y^0,NR^1 + R)$$

where R is resource-based compensation in the form of a vector of resources provided through some set of restoration actions. The goal, then is:

Min C(R)

R

> such that

$$U(P,Y,NR^0) = U(P,Y,NR^1+R)$$

> and

$$C(R) < F_{GD} * [E(P,NR^0,U^0)-E(P,NR^1,U^0)]$$

where C(R) is the cost associated with the restoration program R, F_{GD} is a factor of gross proportions, $E(\bullet)$ is the expenditure function, and $U^0=U(P,Y,NR^0)$ is the without-spill level of utility. Thus, the term in brackets represents the monetary compensation required to obtain the without-spill level of utility. The first constraint requires that the public be made whole through resource-based compensation, R, and the second constraint requires that the cost of restoration not be grossly disproportionate to the value of the restored resource. A constraint of this form is implicit in *Ohio*, where the court suggests "the rule might hinge on the relationship between restoration cost and use value (e.g., damages are limited to three-times the amount of use value).".[77] Thus, the Court's suggestion for "grossly disproportionate" would be based on a factor of gross proportions (F_{GD}) of 3.

      With the exception of the second constraint, this equation system is equivalent to the traditional expenditure minimization problem of utility theory. This formulation is dual to the monetary compensation problem, which is based on the assumption of utility maximization subject to an income constraint.

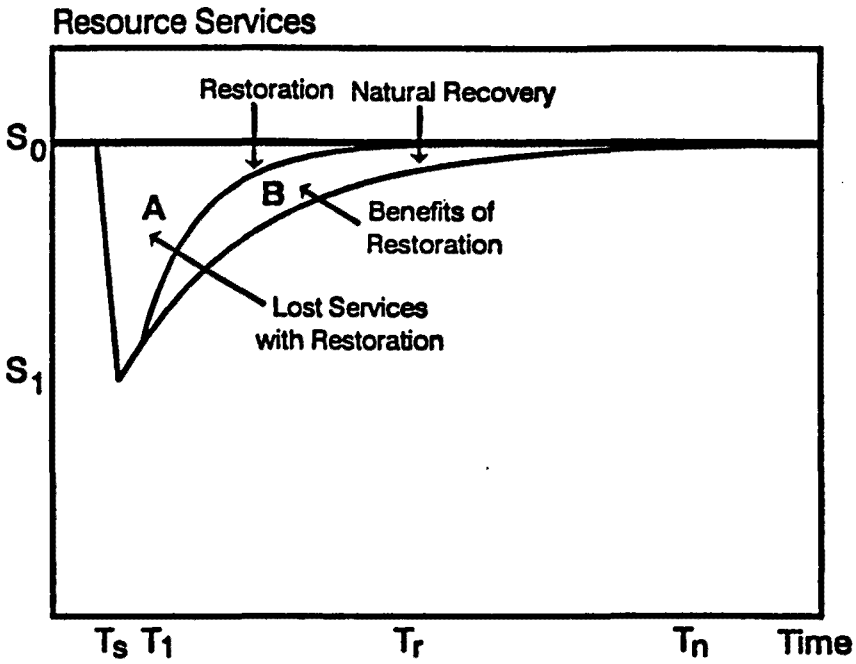77. Ohio v. United States Dep't of the Interior, 880 F.2d 432, 443 n.7 (D.C. Cir. 1989).

Figure 1. Simplified Definition of Restoration
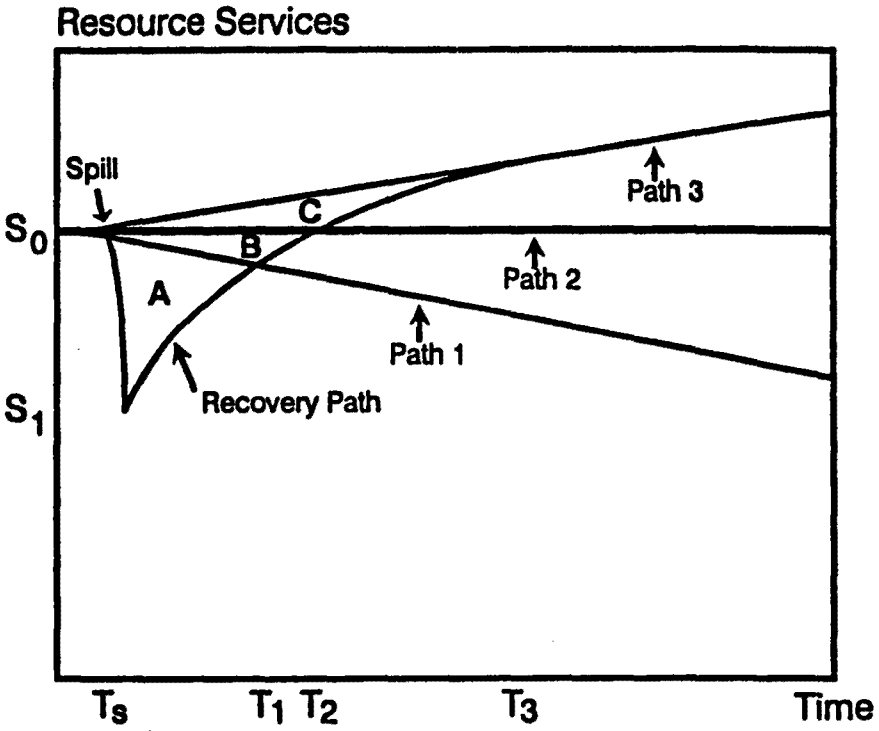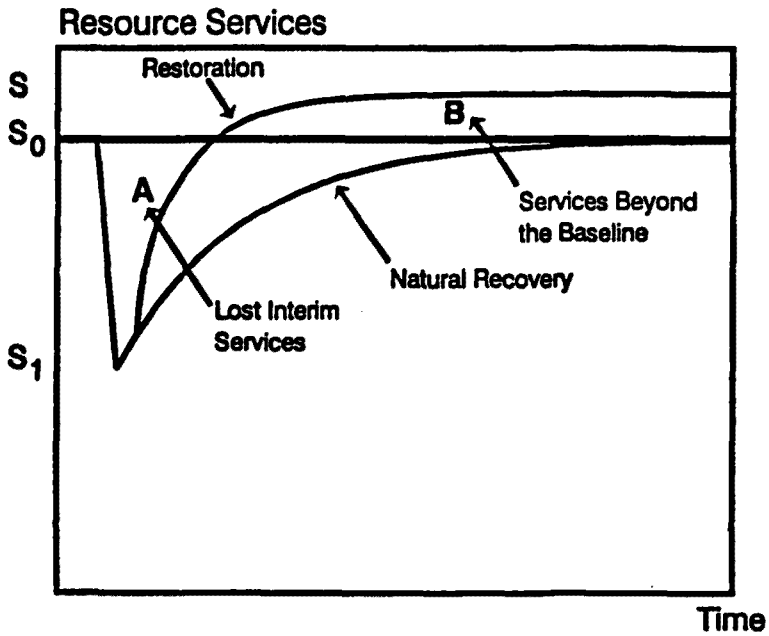
Resource Services

Figure 2. Alternative Baseline Time Paths

Figure 3. Compensation Through Resource Enhancement