COMPENSATORY RESTORATION: ECONOMIC PRINCIPLES AND PRACTICE

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I. BACKGROUND

The Oil Pollution Act of 1990 ("OPA")[1] seeks to "make the environment and public whole for injuries to natural resources and services resulting from an incident involving a discharge or substantial threat of a discharge of oil...."[2] In response, the National Oceanic and Atmospheric Administration ("NOAA") developed regulations in 1996 which focus on restoring such resources and services in lieu of monetary damages for interim losses. These regulations represent a departure from the natural resource damage assessment ("NRDA") regulations promulgated by the U.S. Department of the Interior ("DOI") in 1986.[3] Recent natural resource damage assessments reflect this new focus on compensatory restoration.[4]

The NOAA regulations present new challenges to economists, as well as biologists and ecologists, because they raise questions different from those

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1. Oil Pollution Control Act of 1990, Pub. L. No. 101-380, 104 Stat. 486 (codified at 33 U.S.C. §§ 2701–2761).

2. 15 C.F.R. § 990.10 (1999).

3. *See* 43 C.F.R. pt. 11 (1999).

4. *See generally, e.g.*, TEXAS GENERAL LAND OFFICE, DRAFT DAMAGE ASSESSMENT AND RESTORATION PLAN AND ENVIRONMENTAL ASSESSMENT FOR THE POINT COMFORT/LAVACA BAY NPL SITE RECREATIONAL FISHING SERVICE LOSSES (1999); WISCONSIN DEPARTMENT OF NATURAL RESOURCES, PLAN FOR THE NATURAL RESOURCE DAMAGE ASSESSMENT OF THE LOWER FOX RIVER SYSTEM, WISCONSIN (1999).

previously considered under the DOI regulations. Most importantly, the NOAA approach requires economists to predict how people will alter their use of natural resources in response to possible restoration actions.[5] Thus, economists must measure the benefits of potential restoration actions in addition to measuring the losses associated with the hazardous substance release or oil spill. The objective of compensatory restoration is to provide a level of service flows that will just offset any service losses caused by an oil spill or hazardous substance release.[6]

A consistent conceptual framework is crucial for reliably assessing losses and evaluating the efficacy of various restoration alternatives. Such a framework provides a basis for measuring welfare gains and losses as well as evaluating the adequacy of various measurement approaches. This Article provides such a conceptual framework based on microeconomic theory. The framework provides a useful perspective for examining the NOAA approach to damage assessment, including the potential effectiveness of various methods for evaluating restoration. We also present two stylized examples to illustrate the types of economic issues that arise in implementing compensatory restoration.

II. REGULATIONS

In August of 1995, the NOAA proposed an alternative approach to its NRDA regulations, which were adopted in January of 1996.[7] The NOAA developed the alternative approach in response to extensive comments on an earlier proposal about the reliability of various valuation methods, most notably the use of contingent valuation to measure the losses in nonuse values.[8] Nonuse values are values people may hold for natural resource services that are independent of any anticipated use of the resource.[9] In the original NOAA proposal, nonuse losses and use losses comprised compensable value or the value of the services lost during the time between the occurrence of the injury and the return to baseline.[10] Under the new rule, however, compensatory restoration costs replace compensable value losses.[11] Calculating the value of the interim service losses is replaced with developing a compensatory restoration plan to replace forgone services with equivalent service gains. The responsible party is liable for the cost of that compensatory restoration, rather than the value of the interim service losses.[12]

5. *See* 15 C.F.R. § 990.53(d).
6. *See id.* § 990.53(c).
7. *See* Natural Resource Damage Assessments, Final Rule, 61 Fed. Reg. 440 (1996) (codified as amended at 15 C.F.R. pt. 990 (1999)).
8. *See id.*
9. *See* 15 C.F.R. § 990.30.
10. *See* Natural Resource Damage Assessments, Proposed Rule, 59 Fed. Reg. 1061 (1994).
11. *See* 15 C.F.R. § 990.10.
12. However, if the trustees determine that "valuation of the replacement natural resources and/or services cannot be performed within a reasonable time frame or at a

The NOAA regulations require scaling of compensatory restoration alternatives to estimate the appropriate size of the project.[13] The NOAA identifies two types of scaling: the service-to-service approach and the valuation approach.[14] The service-to-service approach uses a common metric to equalize the lost services and the gain in services.[15] The valuation approach, however, equalizes the dollar value of the lost services and the dollar value of the gain in services from the compensatory restoration project.[16] The service-to-service approach is the NOAA's preferred approach but can be used only when the replacement services are "of the same type and quality" as those lost and are "subject to comparable resource scarcity and demand conditions."[17] The valuation approach may be used when the assumptions required for the service-to-service approach are not met.[18] Although the valuation approach may sound similar to measuring compensable values under the DOI approach, two important differences remain. First, under the compensatory restoration approach, both gains and losses are measured, not simply the losses. Equally important, the basis for damages is the cost of the preferred compensatory restoration projects, not the losses in compensable value.

Many important economic questions arise when a compensatory restoration program is attempted. However, the NOAA regulations provide little insight into the economic issues. Even the supplemental document issued by the NOAA to help practitioners conduct compensatory restoration contains many confusing discussions.[19]

This Article explains compensatory restoration using basic economic principles and concepts. It also draws upon experience gained during the last three years in conducting several NRDAs.

III. NATURAL RESOURCE SERVICES

As discussed above, the NOAA rule places compensation within a framework of services lost as a result of injury and services gained from compensatory restoration actions. This focus is derived from the basic economic concept that people's valuation of a good is based on the services provided by that good. This principle applies to any type of good, whether it is a marketed

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reasonable cost...trustees may estimate the dollar value of lost services and select the scale of the restoration action that has a cost equivalent to the lost value." *Id.* § 990.53(d). Therefore, NOAA allows for monetary compensation equal to the value of interim lost services as a fallback position.

13. *See id.* § 990.53(d).
14. *See id.*
15. *See id.* § 990.53(d)(2).
16. *See id.* § 990.53(d)(3).
17. *Id.* § 990.53(d).
18. *See id.*
19. *See generally* RICHARD W. DUNFORD ET AL., COMMENTS ON NOAA'S DRAFT COMPENSATORY RESTORATION GUIDANCE DOCUMENT (1997).

commodity or a natural resource.[20] For example, people value a house in part because it provides the service of shelter. Likewise, people value the flow of services that come from wetlands, such as hunting, wildlife viewing, or habitat for various species.[21]

With public services such as recreation, people directly experience the natural resource services on-site. Other services, such as habitat for birds or nursery areas for fish, must be perceived as meaningful to people in order to have value. Although benthic organisms provide a service because they are an integral part of the food chain for fish, birds, and other animals, they have measurable value to people only if they provide perceptible direct or indirect human-use services.[22]

Under the NOAA regulations, the essential economic task of NRDAs is to measure the service losses resulting from the release of oil or hazardous substances and to estimate the potential gains that result from restoration actions.[23] To illustrate these tasks, it is useful to consider a hypothetical example of service losses and gains. In Figure 1, *infra*, service losses are shown as Area A. This stylized example shows a reduction from baseline and then a gradual recovery at the injured site. Time *S* represents the start of the spill or release, *P* represents the start of restoration actions, and *R* shows when recovery is completed. The dashed line extending to the baseline from *P* represents the path of natural recovery. Under the DOI regulations, damages are based on the costs of the restoration actions that begin at *P* and the monetary value of the service losses that are shown in Area A.[24]

20. *See* VALUING NATURAL ASSETS: THE ECONOMICS OF NATURAL RESOURCE DAMAGE ASSESSMENT 6–8 (Raymond J. Kopp & V. Kerry Smith eds., 1993) [hereinafter VALUING NATURAL ASSETS].

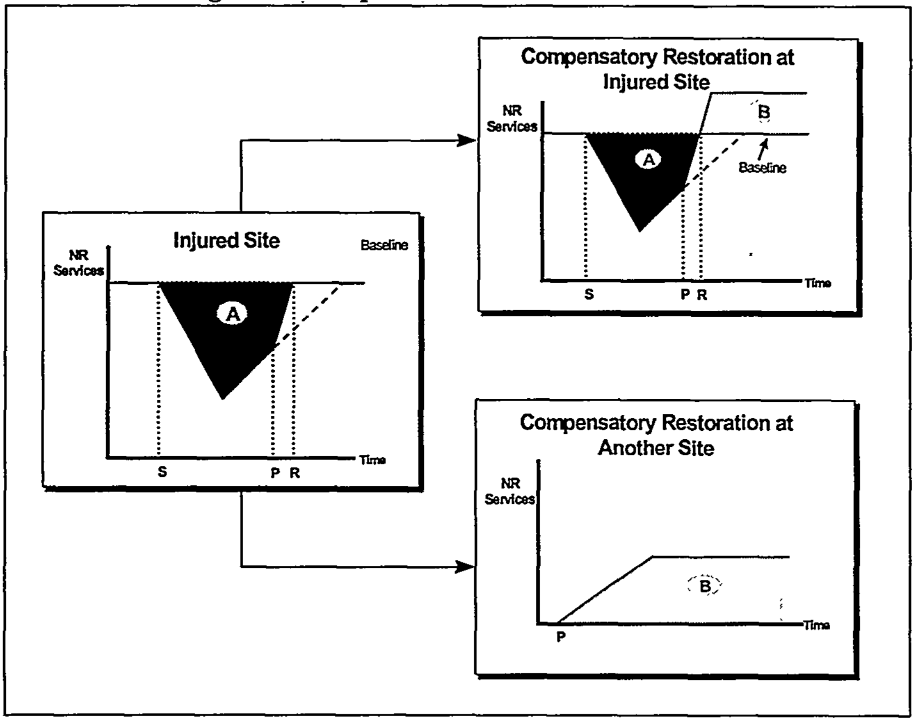
21. In the NOAA regulations, services are defined as "the functions performed by a natural resource for the benefit of another natural resource and/or the public." 15 C.F.R. § 990.30. These services include ecological services and public services. The DOI regulations for hazardous-substance releases describes services as "the physical and biological functions performed by the resources including the human use of those functions." 43 C.F.R. § 11.14 (1999).

22. Although the notion of economic value is based on human welfare, this anthropocentric focus does not mean that individuals do not value species' survival, habitat, or other ecological services.

23. *See* 15 C.F.R. § 990.10.

24. *See* 43 C.F.R. § 11.83.

Figure 1. Example of Service Losses and Gains



The potential service gains from compensatory restoration actions are shown as Area B in Figure 1. As Figure 1 illustrates, compensatory restoration gains may be in one of two forms: restoration of services at the injured site *beyond* baseline or generation of services at another site. As noted above, under the NOAA regulations, damages are based on the costs of primary restoration actions that begin at *P*, and the costs of the compensatory restoration projects needed to achieve the service gains in Area B. Clearly, if the cost of providing a compensatory project is less than the value of the services, the damage is less under the NOAA regulations than under the DOI regulations.[25] Conversely, if the cost of a compensatory project is higher, then the damage is greater.

The timing of compensatory restoration service flows and values is important in the NOAA process. Specifically, the gains must be discounted into present-day values.[26] Discounting recognizes the principle that people prefer to consume goods and services in the present rather than postpone their consumption to some future time. Ordinarily, people must be offered additional compensation before they are willing to postpone consumption. Interest-bearing savings accounts are based on this principle. In order to get people to save money, i.e., forego consumption, banks pay customers an additional amount of money in the form of

25. *Compare* 43 C.F.R. § 11.83, *with* 15 C.F.R. §§ 990.50–.55.

26. *See* 15 C.F.R. § 990.53(d)(4).

interest. Thus, applying a discount rate to account for the future gains over time is appropriate. The NOAA regulations recommend a three-percent discount rate.[27]

To properly evaluate compensatory-restoration actions, it is critical to establish the correct level of baseline services. The NOAA NRDA regulations define baseline as "the condition of the natural resources and services that would have existed had the incident not occurred."[28] Therefore, determining baseline affects all subsequent analysis. For example, if the baseline is set too high, service losses will be overstated and the compensatory gains needed to offset the losses likewise will be overstated. This problem is especially pronounced if compensatory restoration at the injured site is in the form of service gains beyond baseline. In that case, compensatory-restoration actions must generate services beyond an artificially high baseline.

When natural resource damages are assessed, baseline services must reflect the services that would have existed without the injury rather than services before the injury. For example, suppose a release occurred in the 1940s in a pristine environment. Then the area became more industrialized over time, resulting in the building of highways and manufacturing facilities. Consequently, the baseline levels of ecological and human-use services in the area declined over time, completely independent of the release. Therefore, even though the resource was pristine before the release, that is not the appropriate baseline condition for measuring losses. Because the baseline often is dynamic, its correct establishment must incorporate the type of intertemporal changes described above. Furthermore, this "without-injury" perspective complicates the establishment of the baseline because data on the service levels in the absence of the injuries are usually unavailable.[29] Although the relevant temporal changes, such as the addition of highways, should be incorporated when the baseline is established, there may be no time period in the past when highways existed without the injury, making the determination of baseline services difficult. Thus, determining the baseline remains one of the most crucial issues in an NRDA.

IV. ECONOMIC PRINCIPLES

To measure the value associated with service gains and losses, it is essential to place services within a basic economic context. Directly or indirectly, the economic value of services comes from human use of resources.[30] Society

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27. *See* Natural Resource Damage Assessments, Final Rule, 61 Fed. Reg. 440, 454 (1996) (codified as amended at 15 C.F.R. pt. 990 (1999)).

28. 15 C.F.R. § 990.30.

29. *See* NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION, SCALING COMPENSATORY RESTORATION ACTIONS: GUIDANCE DOCUMENT FOR NATURAL RESOURCE DAMAGE ASSESSMENT UNDER THE OIL POLLUTION ACT OF 1990, at 1–7 (1997) [hereinafter NOAA GUIDANCE DOCUMENT].

30. The NOAA regulations define value as "the maximum amount of goods, services, or money an individual is willing to give up to obtain a specific good or service,

seeks to maximize the satisfaction or utility from natural resource services. Utility is defined as the satisfaction that people receive from using a commodity or engaging in an activity.[31] The level of utility depends on people's preferences.[32] Service gains are associated with increases in utility, while service losses are associated with decreases in utility, i.e., disutility. Thus, compensatory restoration actions seek to replace the lost utility associated with an injury.

An individual may experience the same level of utility from many different combinations of natural resource services. For example, someone may enjoy equally having three fishing days and five park-use days or having two fishing days and seven park-use days during a given month. The important economic information to obtain is the rate at which people are willing to trade off different quantities of services. With this information, an economist can evaluate a much wider range of restoration projects than is possible under the strict "service-to-service" interpretation that requires services to be of the same type and quality. Thus, using a utility-based approach makes it possible to compare projects that provide a wider range of services. Equally important, utility-based approaches do not require that the losses and gains be monetized.[33] This may help to avoid some of the contentious issues in a damage assessment, while still providing measures of losses and gains that are based on sound economic principles. As discussed below, several measurement methods can produce utility-based estimates.

V. METHODS FOR SCALING

There are five basic methods that we will discuss for quantifying utility losses and scaling potential restoration gains: Benefits Transfer, Contingent Valuation ("CV"), Random Utility Models ("RUMs"), Stated Preference/Conjoint Analysis, and Habitat Equivalency Analysis ("HEA"). Table 1 provides an overview of each method, focusing on its use for quantifying both utility losses and restoration gains.

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or the minimum amount of goods, services, or money an individual is willing to accept to forgo a specific good or service." 15 C.F.R. § 990.30.

31. *See* VALUING NATURAL ASSETS, *supra* note 20, at 341.

32. To convert individual utility into societal utility, we make the simplifying assumption that individuals have similar preferences that can be combined. In practice, however, preferences are not the same across individuals and should be modeled as a function of personal characteristics like age, income, and other variables.

33. *See* Natural Resource Damage Assessments, Final Rule, 61 Fed. Reg. 440, 454 (1996) (codified as amended at 15 C.F.R. pt. 990 (1999)).

Table 1a. Comparison of Scaling Approaches

Method	Benefits Transfer	Contingent Valuation	Random Utility Models
Underlying Premise	Value of a recreation site based on values of existing similar sites.	Value of a good in hypothetical markets reflects the value that good would have in an actual market.	Value of a recreation site is a function of the value of each of its characteristics.
Services Addressed	Use services, losses and gains.	Use and ecological services, losses and gains.	Use services, losses and gains.
Data Required	Data on use of reference site and values of the use.	Survey data on willingness to pay for hypothetical good or program.	Survey data on visitation and site characteristics for competing sites by people within the relevant geographic market.
Statistical Complexity	Low. If a reference site and data are available, analysis is straightforward.	Low to High. Analysis ranges from very simple univariate statistics to highly complex models.	Moderate to High. The application of RUMs to recreation modeling is complex but many empirical studies exist.
Ability to Evaluate Multiple Compensatory Restoration Alternatives	Well-suited for valuing use services where appropriate reference sites exist, data are available, and estimates are needed promptly.	Useful only if the restoration alternatives are known in advance of the survey development and contingent market scenarios can be devised to represent them. Then, potentially, different versions for each alternative could be administered to separate samples. Unreliable when applied to ecological services. Subject to overstating losses and gains.	Well-suited for valuing different bundles of characteristics resulting from compensatory restoration alternatives as long as those characteristics are included as site characteristics in the model. Based on actual behavior, which provides reliable estimates.

Table 1b. Comparison of Scaling Approaches, continued

Method	Stated Preference/ Conjoint Analysis	Habitat Equivalency Analysis
Underlying Premise	Value of a good is determined by its characteristics.	Lost resource services can be offset with replacement services without valuation.
Services Addressed	Use and possibly ecological services, losses and gains.	Ecological services, losses and gains
Data Required	Survey data on trade-offs of hypothetical bundles of characteristics.	Services data only. No data on preferences. However, input parameters for assessing services may be expensive to measure if literature-based values are not available.
Statistical Complexity	Moderate to High. Complex statistical models are required to properly estimate the utility changes for changes in characteristics.	Low. If the strict assumptions are met, the analysis is straightforward.
Ability to Evaluate Multiple Compensatory Restoration Alternatives	Well-suited for valuing different bundles of characteristics resulting from compensatory restoration alternatives as long as those characteristics are included in the model. Has not been applied to ecological services. Subject to overstating losses and gains.	If compensatory restoration alternatives yielding services of the same type and quality as those lost can be identified, HEA can be useful for evaluating alternatives. Assumes people's preferences are such that they want the same services as compensation.

A. Benefits Transfer

Benefits transfer is the most frequently used method for valuing the services of a natural resource because researchers are able to use existing studies and data to estimate or predict values.[34] When the transfer method is used, the analysis is limited to only those scaling methods for which adequate data are available. Transfer studies are used most often in cases where ample data are available for the site of interest, where there is less uncertainty about the potential magnitude of gains and losses, or in situations where estimates are needed in a short period of time.

The NOAA states that any resource value developed through an administrative or legislative process may also be used in a benefits transfer study.[35] In a basic benefits transfer, the researcher selects the best study from a range of

34. *See* VALUING NATURAL ASSETS, *supra* note 20, at 329.

35. *See*, Natural Resource Damage Assessments, Notice of Proposed Rulemaking, 59 Fed. Reg. 1062, 1148 (1994).

studies that use various valuation techniques and transfers the per-unit value from that study to the current study. The studies should meet the principles of scientific soundness and should value similar resources.[36] More advanced benefits transfer techniques use equations and models to adjust the value to better reflect the services affected.[37]

Besides developing a value in a benefits transfer, the researcher must quantify the unit losses or gains, such as a fishing day or a park-use day. The reference site approach provides the relevant unit losses or gains to apply to the transferred value of a use day. The reference site approach is a well-recognized scientific approach for this type of estimation. The DOI regulations describe the use of reference sites, referred to as control areas.[38]

B. Contingent Valuation ("CV")

Contingent valuation asks respondents directly about their willingness to pay ("WTP") for a commodity. Instead of focusing on the services themselves, CV typically elicits WTP by focusing on an environmental program that restores services.[39] CV has many well-documented problems that stem from its hypothetical nature, especially when used to measure nonuse values.[40]

At the time of the NOAA panel, no reliable reference CV survey existed. Therefore, using CV surveys in a NRDA to elicit WTP estimates requires the survey designers to prove the reliability of the survey. CV surveys are considered unreliable if there is: a high nonresponse rate, inadequate responsiveness to the scope of the injury, lack of understanding of the task by the respondents, lack of belief in the restoration program, or failure to present cost or value of the hypothetical program.[41]

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36. *See* William H. Desvousges et al., *Benefits Transfer: Conceptual Problems in Estimating Water Quality Benefits Using Existing Studies*, 28 WATER RESOURCES RESEARCH 675, 676–77 (1992).

37. *See* John B. Loomis, *The Evolution of a More Rigorous Approach to Benefit Transfer: Benefit Function Transfer*, 28 WATER RESOURCES RESEARCH 701, 704 (1992); V. Kerry Smith, *On Separating Defensible Benefit Transfers from "Smoke and Mirrors"*, 28 WATER RESOURCES RESEARCH 685, 692–93 (1992).

38. *See* 43 C.F.R. §11.72(d) (1999).

39. *See* 2 NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION, PROSPECTIVE INTERIM LOST USE VALUE DUE TO DDT AND PCB CONTAMINATION IN THE SOUTHERN CALIFORNIA BIGHT 19–21 (1994) [hereinafter LOST USE VALUE IN THE SOUTHERN CALIFORNIA BIGHT].

40. *See generally* CONTINGENT VALUATION: A CRITICAL ASSESSMENT (J.A. Hausman ed., 1993). See also Natural Resource Damage Assessments Under the Oil Pollution Act of 1990; Advance Notice of Proposed Rulemaking, Extension of Comment Period, and Release of Contingent Valuation Methodology Report, 58 Fed. Reg. 4601 (1993) for a full discussion.

41. *See* 58 Fed. Reg. at 4609.

One of the challenges with CV is to design a hypothetical program that reflects the actual service losses at the site. Even if this challenge is met, existing applications of CV typically value only one program and thus lack the flexibility of estimating values for different compensatory restoration actions.[42] Ideally, a technique should allow for the valuation of different levels of a characteristic or different combinations of characteristics so that numerous restoration actions can be evaluated. This evaluation would be possible only if multiple CV scenarios were designed and administered. Even in this case, the compensatory restoration alternatives must be known in advance of the survey design and the number of respondents needed may be prohibitive.[43] Combined with the reliability concerns for nonuse values, CV is of limited use for scaling gains.

C. Random Utility Models ("RUMs")

In our view, the RUM is the best available tool for valuing recreation services. Most economists support the use of RUMs, as do the NRDA regulations.[44] The Clark Fork River and *Exxon Valdez* NRDAs used RUMs to estimate recreation losses, and the methodology is endorsed by trustees in current NRDAs.[45] RUMs use the cost of travel as an implicit price; the value of a site is modeled as a function of the values of its characteristics.[46] By taking this

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42. *See* LOST USE VALUE IN THE SOUTHERN CALIFORNIA BIGHT, *supra* note 39, at 19–21.

43. *See* W.G. COCHRAN & G.M. COX, EXPERIMENTAL DESIGNS 151 (2d ed. 1992).

44. *See, e.g.*, Nancy E. Bockstael et al., *Recreation*, *in* MEASURING THE DEMAND FOR ENVIRONMENTAL QUALITY 227 (John B. Braden & Charles D. Kolstad eds., 1989); W. Adamowicz et al., *Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities*, 26 J. ENVTL. ECON. & MGMT. 271 (1994); Michael D. Creel & John B. Loomis, *Modeling Hunting Demand in the Presence of a Bag Limit, with Tests of Alternative Specifications*, 22 J. ENVTL. ECON. & MGMT. 99 (1992); Peter M. Feather, *Sampling and Aggregation Issues in Random Utility Model Estimation*, 76 AM. J. AGRIC. ECON. 772 (1994); Jerry A. Hausman et al., *A Utility-Consistent, Combined Discrete Choice and Count Data Model: Assessing Recreational Use Losses Due to Natural Resource Damage*, 56 J. PUB. ECON. 1 (1995); Yoshiaki Kaoru et al., *Using Random Utility Models to Estimate the Recreational Value of Estuarine Resources*, 77 AM. J. AGRIC. ECON. 141 (1995); Edward R. Morey et al., *A Discrete-Choice Model of Recreation Participation, Site Choice, and Activity Valuation When Complete Trip Data Are Not Available*, 20 J. ENVTL. ECON. & MGMT. 181 (1991); George R. Parsons & Michael S. Needelman, *Site Aggregration in a Random Utility Model of Recreation*, 68 LAND ECON. 418 (1992); W. Douglas Shaw & Peter Jakus, *Travel Cost Models of the Demand for Rock Climbing*, AGRIC. & RESOURCE ECON. REV., Oct. 1996, at 133.

45. *See* WILLIAM H. DESVOUSGES & STEVEN M. WATERS, REPORT ON POTENTIAL ECONOMIC LOSSES ASSOCIATED WITH RECREATION SERVICES IN THE UPPER CLARK FORK RIVER BASIN 1 (1995); STATE OF MONTANA NATURAL RESOURCE DAMAGE PROGRAM, ASSESSMENT OF DAMAGES TO ANGLERS AND OTHER RECREATORS FROM INJURIES TO THE UPPER CLARK FORK RIVER BASIN 1–8 (1995); Hausman et al. *supra* note 44, at 3–4.

46. *See* VALUING NATURAL ASSETS, *supra* note 20, at 185–88.

approach, RUMs can determine the relative importance of each site characteristic by evaluating the trade-offs made by recreators among those characteristics.

The focus on site characteristics permits the isolation of the effect of each characteristic on the recreation activity. To investigate a particular site characteristic, all other site characteristics are held constant. The better the characteristics of a site, the higher the probability that a recreator will choose that site, and thus the higher the value of that site. RUMs can be used to predict the quantity of additional recreation that would take place if the injury were not present or under different compensatory restoration scenarios, making RUMs much more useful than traditional travel-cost models for scaling losses and gains.

D. Stated Preference/Conjoint Analysis

Stated preference analysis is based on the premise that products are composed of various characteristics, and the value of the composite good is a function of the value of its characteristics.[47] This premise is consistent with the underlying economic models used in RUMs and hedonic studies. Stated-preference models recover the utility for each characteristic by asking respondents a series of questions and trading off pairs of products with varying characteristics.[48] Respondents either choose one of the two products or rate one product relative to another. In a damage assessment setting, respondents are asked to evaluate service losses or gains through trading off environmental programs with different characteristics.[49] Then the observed trade-offs between characteristics can be used to estimate the change in utility associated with either increases or decreases, i.e., gains or losses, for a characteristic, such as fish-consumption advisory levels.

Stated preference analysis has potential advantages over other techniques. One main advantage is that its flexibility allows for the creation of characteristics that may not exist currently. This flexibility can be crucial for measuring compensatory restoration gains. For example, a restoration program in a stated preference exercise may include recreation facilities that are not currently available in the area of the release. Despite the fact that they do not yet exist, stated preference analysis can discover individuals' utility for these characteristics. Furthermore, because stated preference analysis values characteristics separately,

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47. Although the NOAA regulations refer to this technique as conjoint analysis, stated preference is the more common name in economic practice. *See* Natural Resource Damage Assessments, Final Rule, 61 Fed. Reg. 440, 499 (1996) (codified as amended at 15 C.F.R. pt. 990 (1999)).

48. *See* RICHARD W. DUNFORD ET AL., NONUSE VALUES FOR NONENVIRONMENTAL COMMODITIES: PRELIMINARY CONJOINT SURVEY RESULTS (1995) (draft report on file with Triangle Economic Research).

49. *See* Kristy E. Mathews et al., *Using Economic Models to Inform Restoration Decisions: The Lavaca Bay, Texas Experience, in* CONFERENCE ON RESTORATION OF LOST HUMAN USES OF THE ENVIRONMENT 3–4 (1997).

different combinations of characteristics can be grouped together and the resulting compensatory restoration project can be valued. CV typically only values one program, so it does not have this flexibility.

Nonetheless, stated preference analysis is based on hypothetical choices, not real behavior. As such, the results may be subject to hypothetical bias, resulting in overstated losses or gains. In some cases, the bias in overstating losses may be offset by overstated gains. However, there is no reason to assume that this will be the case. The factors that lead to the bias could have more undue influence on either the losses or the gains. Stated preference analysis for evaluating restoration has not been used in a damage assessment that has been litigated nor has it been applied to ecological services in a damage assessment.

E. Habitat Equivalency Analysis ("HEA")

The NOAA regulations recommend using HEA for service-to-service scaling, especially when the lost services are primarily ecological services, such as species habitat or biological services.[50] HEA is based on the idea of compensating for lost services by replacing them with an equivalent flow of services.[51] Compensation may occur by creating new habitat or improving injured habitat beyond baseline (in cases where the habitat was not at its maximum potential at baseline).

The HEA approach is based on the fundamental goal of equating the monetary value of service losses to the monetary value of service gains.[52] Thus, the utility framework developed in this Article is applicable to HEA. However, HEA makes very restrictive assumptions to eliminate monetary values from the calculations, avoiding the need to use economic valuation techniques to scale the compensatory restoration actions.[53] In general, HEA requires the services lost from the injury and the services gained through compensatory restoration to be of the same type and quality and to face the same market conditions over the relevant time frame.[54] Under these assumptions, the per-unit value of lost services and gained services would be the same over time, which results in eliminating them from the calculation. Therefore, we can compare the quantity of service flows and still compare the utility of those service flows, maintaining the conceptual framework underlying the behavioral models and stated preference models.

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50. *See* NRDA, Final Rule, 61 Fed. Reg. at 453.

51. A basic tenet of economic theory holds that individuals can best determine how to maximize their own utility. Under this provision, replacing the lost service flows may be inferior to other possible uses of the money needed to replace those service flows.

52. *See* Robert E. Unsworth & Richard C. Bishop, *Assessing Natural Resource Damages Using Environmental Annuities*, 11 ECOLOGICAL ECON. 35, 36–37 (1994).

53. *See id.* at 37.

54. *See* 15 C.F.R. § 990.53(d) (1999).

HEA has been used to provide a basis for settling some ecological resource service losses in NRDAs.[55] The approach is used in lieu of trying to value such resource services with CV, which has demonstrated reliability problems and can be expensive to implement. However, these applications occurred in situations where equivalent resources were located nearby and could be enhanced at a reasonable cost. In some HEA applications, the parameters of the model are adjusted in such a way as to offset violations of its restrictive assumptions. Whether such adjustments lead to the appropriate compensation is an open empirical question.

VI. STYLIZED EXAMPLES

We present two stylized examples as practical applications of scaling compensatory restoration. These hypothetical examples are drawn from practical experience gained in several NRDAs since the passage of the NOAA regulations.

A. Example 1: Compensatory Restoration for Groundwater/Surface Water Contamination Using the Transfer Method and HEA

Suppose that a hazardous substance is released into an aquifer that discharges to a stream, causing both ecological and human-use service losses. Suppose also that the most important ecological losses involve the contamination of wetlands adjacent to the stream. The hypothetical human-use service losses include two components. First, the contaminants reduce the volume of drinking water from the aquifer available for future use. Second, recreational fishing opportunities are lost because of a ten-year fishing ban in the stream.

As noted above, the transfer method uses available data and studies to estimate losses and gains. For drinking water, recreational fishing, and ecological services, demand data from the site itself or a reference site provides estimates of the use of the resource. Market data provides the current supply and possible substitutes. Finally, current literature provides value estimates for each service.

Determining the baseline is one of the most critical tasks in a damage assessment. For this example, baseline drinking water is the volume available without the release during a year with typical precipitation. Hence, baseline is understated if the year when the volume is measured is very dry. On the other hand, a very wet year could overstate the baseline.

For recreational fishing, baseline is the number of angling days without the release. As in the drinking water case, baseline can be understated or overstated by weather-related conditions. In addition, baseline may include such factors as water quality, prevalence of anglers, access to the stream, and other factors that change through time and that could affect the number of angling days.

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55. *See* NOAA GUIDANCE DOCUMENT, *supra* note 29, at D-2.

Finally, for wetland services, baseline considerations include the types of flora and fauna supported by the marsh, the number of acres of habitat available for those species, and the carrying capacity of the marsh. Measuring baseline requires ecologists to determine the extent of the marsh's functioning without the substance release.

In the case of drinking water, a transfer can provide the volume of water gains necessary to offset the lost drinking water. In this hypothetical example, the present discounted volume of drinking water lost from the substance release is 100 acre-feet. Water savings of acre-feet from conservation measures can offset the lost acre-feet.

Compensatory restoration projects may include a wide range of alternatives. For example, it may be possible to increase the amount of drinking water available by providing a new well for the municipal system or by helping to improve the efficiency of the existing distribution system.[56] Alternatively, the restoration projects might consider ways to increase the volume of water into the contaminated aquifer or other aquifers that could provide drinking water.[57] Additionally, it may be possible to improve the efficiency in use for various purposes.[58] For example, substantial amounts of water may be lost through inefficient household use of toilets and showerheads. By providing a water conservation package with devices like low-flow showerheads and toilet-tank inserts, it is possible to make more drinking water available. Thus, the volume of water saved through conservation compensates for the volume of water unavailable for drinking as a result of the release. Table 2 shows the hypothetical gains from mitigation projects in acre-feet per household.

Table 2. Hypothetical Gains from Mitigation Projects

Conservation Method	Present Discounted Value of Acre-Feet of Water Gained per Household in 10 Years	Number of Participating Households Necessary to Mitigate 100 Acre-Feet
Low-flow showerheads	0.20	500
Toilet tank inserts	0.15	667

Benefits transfer can estimate the value of lost angling services associated with the fishing ban as well as the value of gains from potential restoration projects. Suppose for example, based on reference sites, the annual angling losses are 5000 days. Suppose also that reference sites provide estimates of the average annual angling days gained above baseline. For this example, we assume that improved boat launch facilities would add 5500 days, and a new boat launch

56. *See* NATIONAL RESEARCH COUNCIL, VALUING GROUND WATER: ECONOMIC CONCEPTS AND APPROACHES 22–23 (1997).

57. *See id.*

58. *See id.*

would add 6000 days.[59] Finally, suppose also that the research literature has a meta-analysis, which provides the per-day value for angling, $10. The product of average annual angling days and the per-day value estimates measures the average annual value of the hypothetical gains—$55,000 and $60,000, respectively—and the annual value of losses—$50,000.

To evaluate the total losses and gains, we must consider the number of years that each exists. For example, suppose that the fishing ban was in place for ten years and that both restoration projects will have a fifteen-year life. Discounting provides a means to compare the present value of the flow of past service losses to the flow of future service gains. The present value of the losses is $665,000. Table 3 provides the present value of the future gains from each restoration project. As the table shows, only the new boat launch provides enough value gain to offset the lost angling value from the hazardous substance release.

Table 3. Hypothetical Gains in Angling Days

Reference Site	Increment in Average Annual Angling Days	Per-Day Value of Angling	Average Annual Value of Angling	Years of Gain	Present Value
Improved boat launch facilities	5,500	$10	$55,000	15	$657,000
New boat launch	6,000	$10	$60,000	15	$716,000

Finally, habitat equivalency analysis provides an estimate of the surface acres of marsh necessary to replace the reduction in marsh services. In this hypothetical example, marsh services are reduced by fifteen percent for twenty years. The compensatory restoration action is intended to create additional marsh habitat to increase ecological services. In our hypothetical example, a ten-acre marsh over thirty years will produce a level of ecological services equivalent to those lost. The new acres of marsh also provide fish-spawning habitat. The increased spawning habitat will increase fish populations and may increase angler days.

Despite the fact that the NOAA rule specifies two distinct services—ecological services and human-use services—it is important to avoid a simple summation of the value of the losses or gains when using different methods for different services.[60] In the example above, simply adding the cost of the increased angler days and the cost of the increased marsh habitat will overstate restoration because the marsh habitat restoration action may increase angler days. Thus, the

59. *See infra* tbl.3.

60. *See* Natural Resource Damage Assessments, Final Rule, 61 Fed. Reg. 440, 448 (1996) (codified as amended at 15 C.F.R. pt. 990 (1999)).

only angler days for which compensation is required are the days not gained from the marsh enhancement. Scaling compensatory restoration for these services in isolation, therefore, likely will lead to undercounting and an inefficiently high level of compensatory restoration action.[61]

B. Example 2: Compensatory Restoration for Fish Consumption Advisories in a River

This hypothetical example illustrates the use of original studies to estimate potential losses and gains from compensatory restoration. Original studies typically include primary data collection for the purpose of estimating losses and gains specific to the site.[62] Because original studies provide the opportunity to collect a wider range of data than is possible in a transfer, the range of potential approaches for scaling restoration is broader. Original studies may be necessary in cases where little or no data exist, where substantial uncertainty exists about the magnitude of gains and losses, or where the site has unique features that limit a reliable transfer study.

For example, suppose that a hazardous-substance release in a river causes recreational fishing losses because concentrations of the substance in fish tissue result in fish-consumption advisories. In this hypothetical example, we assume that a survey was conducted of recreational anglers who live in the three counties adjacent to the river. Based on available information, anglers from these counties account for most of the recreational fishing trips to the river. The hypothetical survey collected data on anglers' fishing trips during the angling season. Data were obtained from various sources on the characteristics of the sites that anglers visited during the season.

The data provide the basis for estimating a RUM, a widely used approach for modeling recreational fishing choices. The RUM compares the characteristics of each angler's chosen site to the characteristics of all the other sites the angler could have chosen. Therefore, the model requires information regarding the site each angler selects on each trip. To understand the trade-offs each angler makes, it also is necessary to know the characteristics of each site the angler could visit in addition to the site of interest. These characteristics could include facilities, access conditions, site size, number of fish caught, species of fish caught, and the distance

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61. The definitions of ecological and human-use services in the NOAA regulations are not mutually exclusive, which increases the likelihood of undercounting. Specifically, ecological services are defined as functions that one natural resource provides for another and human-use services include functions of natural resources that provide value to the public. *See id.* at 448. Thus, functions provided by one natural resource for another that are also valued by the public are included in both categories.

62. In some cases, it is possible to use one data collection to support both the remediation process and the NRDA. For example, a survey of recreation anglers can be used to estimate a RUM model as well as to provide data for a baseline risk assessment.

traveled to the site. Thus, RUMs use the choices of anglers to understand the relative importance of various characteristics.

The RUM can estimate both the lost utility associated with the fish-consumption advisory as well as the utility gains from restoration projects by measuring the change in utility for an added site or enhancements to existing sites. Table 4 illustrates the results from a simplified RUM.

Table 4. RUM Results: Hypothetical Fishing Example

Characteristic	RUM Coefficient	New Launch	New Pier
Distance from site (miles)	-2.2	15	20
Average number of fish caught per trip	1.8	10	8
Number of launch lanes	1.3	2	N/A
Length of pier (feet)	0.8	N/A	300
Fish-consumption advisory (yes/no)	-0.5	yes	Yes

Hypothetical RUM coefficients provide a ranking of the characteristics for anglers' site selection. As Table 4 shows, the most influential characteristic on fishing-site choice is the distance from the site. Distance from the site has a negative influence on angler utility. Conversely, catching fish, the number of launch lanes, and the length of the pier at the fishing site increase angler utility. Finally, the presence of a consumption advisory at a site decreases angler utility.

To estimate losses and gains, it is necessary to specify the baseline conditions. Using a RUM simplifies this process because the model holds constant the other characteristics such as catch rate or launch facilities.[63] In effect, the model estimates the loss in utility that results only from the consumption advisory. The analysis provides a basis for measuring the level of utility had the advisory not been present. For restoration projects, the model predicts the increased utility that would be gained if a new pier or boat launch were added. Suppose in this example, that the utility loss is measured to be 100. Suppose also that the two possible restoration projects are a new boat launch with two lanes and a new 300-foot fishing pier.[64] For these examples, the hypothetical pier would increase utility to 112 while the hypothetical launch would increase utility only to 79. Thus, only the new pier would provide gains greater that the utility loss.

Alternatively, restoration projects to enhance recreation activities other than fishing could be developed. Such activities could take place in parks located

63. There may be other baseline factors that are addressed outside the model. For example, the RUM is used to address fishing in a particular season. However, it is also necessary to estimate historical and future losses, which may be affected by fish abundance, water quality, or the popularity of angling.

64. *See supra* tbl.4.

near the affected river. For this type of compensatory restoration, additional data are needed about outdoor recreation trips. The outdoor recreation data are similar to the fishing data. As with fishing trips, the RUM compares the characteristics of each recreator's chosen site to the characteristics of all the other sites the recreator could have chosen. These characteristics could include facilities available at the site, the length of trails at the site, the size of the site, and the distance traveled to the site. For the purpose of this example, we assume that anglers provide the outdoor recreation trip information in the same survey. Anglers are not the only ones to gain from outdoor recreation projects. The survey population could be broadened to include more recreators.

As with the fishing projects, the RUM can estimate the utility gains from a restoration project for outdoor recreation. The RUM measures the change in utility for an added site or enhancements to existing sites. Table 5 illustrates the results from an outdoor-recreation RUM.

Table 5. RUM Results: Hypothetical Outdoor Recreation Example

Characteristic	RUM Coefficient	New Park
Distance from site (miles)	-3.0	15
Existence of picnic tables (yes/no)	2.6	Yes
Trail at the site (miles)	1.9	4
Size of the site (acres)	0.4	38

The RUM coefficients provide a ranking of the characteristics for outdoor recreators' site selection. As Table 5 shows, the most influential characteristic on site choice is the distance from the site. Distance from the site has a negative influence on utility for outdoor recreators. Conversely, picnic tables, miles of trail, and the size of the site increase utility. To estimate utility gains from restoration projects for outdoor recreation, it is possible to add characteristics to existing sites or add a new park and estimate the increase in utility.[65]

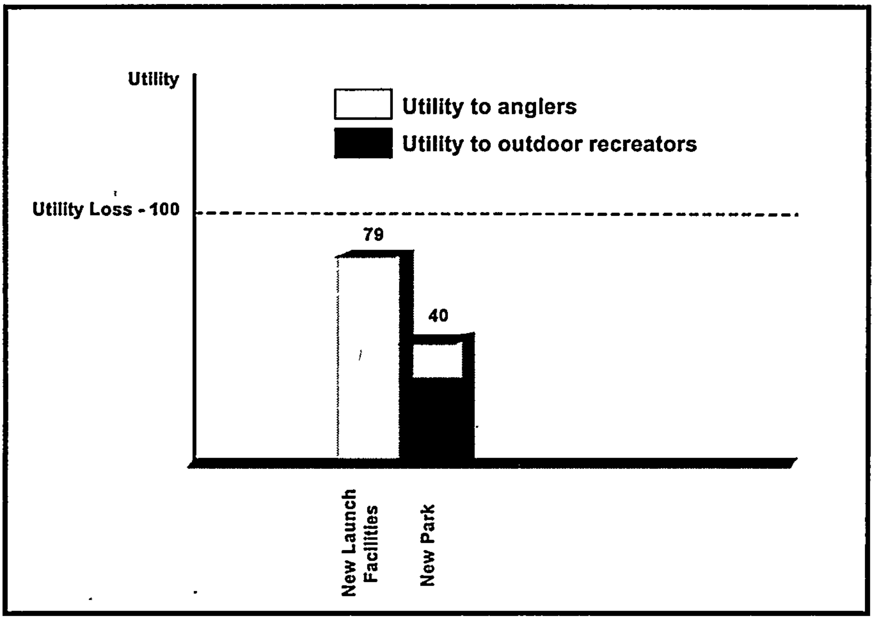
As is the previous example, suppose that the utility loss is measured to be 100. Suppose also that both a fishing project and an outdoor recreation project are possible restoration alternatives. This example considers the same hypothetical two-lane boat launch as the previous example. In addition, this example considers a hypothetical new park near the affected river with four miles of trail.[66] The boat launch provides increased angling opportunities and therefore increased angler utility. The new park also provides utility for both anglers and outdoor recreators. As in the previous example, the hypothetical launch would increase utility to

65. This example assumes that the presence of a fish-consumption advisory affects only fishing and not other outdoor recreation activities. Thus, only gains are estimated for the projects.

66. *See supra* tbl.5.

seventy-nine. In this example, the hypothetical park would increase utility to forty. Thus, neither project on its own provides enough utility gains but added together the projects provide utility gains greater than the utility loss. Figure 2 below illustrates the angler utility gains estimated for the new launch and the angler and outdoor recreator utility gains estimated for the new park, relative to the utility loss. As the figure shows, neither project on its own provides utility gains equal to utility losses. However, the combined projects provide utility gains equal to utility losses.[67]

Figure 2. Utility Gains from Fishing and Outdoor-Recreation Restoration Projects



This stylized example shows the versatility of the RUM. It can be used to measure utility gains from compensatory restoration projects that may affect only one activity or more than one activity. This flexibility increases the range of projects that can be evaluated, which may be an important consideration in some NRDAs. For example, the opportunities for improving fishing may be limited by factors that cannot be changed, such as the location of railroad tracks or the presence of industrial facilities. The ability to measure individuals' trade-offs of fishing for park use or other outdoor recreation yields a measure of restoration benefits that is based on sound economic principles. From a practical perspective, the broader range of recreation activities may be more attractive to area residents,

67. We assume that the losses and gains are properly discounted as in the earlier example.

which may result in a restoration plan that is more likely to survive the public-comment process.

All the hypothetical examples given above describe projects with characteristics that currently exist. Suppose we wanted to consider a restoration project that has characteristics not currently available. Stated preference analysis can be used in such cases. As described above, stated preference models recover the utility for each characteristic by asking respondents to choose between hypothetical fishing trips or park use trips that have varying characteristics. Therefore, respondents would trade off characteristics that are potentially important in the restoration projects.

Stated preference data can be used in a RUM on its own or combined with other data. For example, a RUM could include the needed data on angler trips, as summarized above, and the data from the stated preference questions. The combined data therefore includes trade-offs between revealed angler choices and hypothetical choices among anglers and non-anglers. The combined data allow the RUM to estimate gains in utility using the relative importance of characteristics as shown by both actual choices and hypothetical choices. Since hypothetical stated preference trade-offs can result in overstated losses or gains, as noted above, the data on actual choices may be needed to calibrate the stated-preference responses.

VII. CONCLUSION

The measurement of utility trade-offs for service gains poses new challenges for economists. One of the most important challenges for use services is linking possible restoration actions to individuals' choices. Some of the choices may involve services, such as providing drinking water, that are traded in markets. For these services, the greater availability of data enhances the opportunities for evaluating restoration actions. The parallels between water conservation issues and natural resource damage questions further expand the amount of available data and modeling that can be used in evaluating drinking water issues. Nevertheless, the market for drinking water involves some unique institutional features, such as varying types of property rights and ownership arrangements, which may complicate the economic analysis.[68] The supply side of the drinking water market also involves complicated long-term planning aspects that are equally challenging.[69]

For recreation services the outlook is promising as well. Although markets do not exist for these services, economists have gained considerable experience in developing methods for valuing these services.[70] Based on the experience gained to date, the research findings have considerable relevance for

68. *See* CHARLES HOWE, NATURAL RESOURCE ECONOMICS: ISSUES, ANALYSIS, AND POLICY 311–15 (1979).

69. *See id.* at 282–95.

70. *See* V. Kerry Smith, *Can We Measure the Economic Value of Environmental Amenities?*, 56 SOUTHERN ECON. J. 865, 867–76 (1990).

evaluating recreation restoration projects. As shown in this Article, RUMs provide a well-established method for measuring the benefits of restoration projects. Equally important, the same RUMs can be used to measure losses in recreation services. This eliminates the differences in modeling assumptions or features as a source of disparity in evaluating losses and gains. Although the data needed to estimate a RUM impose substantial requirements, these data could be obtained as part of the remediation process, which would result in a more cost-effective damage assessment. RUMs also can be estimated with data from actual and hypothetical choices. Finally, when RUMs are used in a compensatory restoration framework, it is not necessary to monetize either the losses or the gains. This reduces some of the contentious issues surrounding monetization, including the need to measure the opportunity cost of time.

Nevertheless, many difficult and controversial economic issues still remain in NRDAs based on compensatory restoration. The measurement of baseline can be a contentious issue. Trustees and potentially responsible parties can have dramatically different interpretations of the baseline conditions of natural resource services. These differences can be especially pronounced for sites located in industrialized areas and in mining sites. Developing the necessary information on resource service levels and determining the various factors that have influenced these services remain formidable tasks.

The challenges are substantial for evaluating gains in ecological services. Habitat equivalency analysis has become the method of choice for measuring losses in ecological services and the potential gains from restoration.[71] It is too early to tell whether HEA will have the intended result of achieving restoration sooner. Moreover, it is unclear whether sufficient quality controls can be developed so that HEA is reliably implemented.

Additionally, little experience has been gained on utility-based measures for ecological services. These methods require people to make choices that involve trading off various ecological characteristics. Whether people can conceive of such trade-offs or perform the required cognitive tasks is an open question.

Finally, economics continues to play an important role in NRDA with the regulatory focus on compensatory restoration. Economics has the predominant role in measuring the losses and gains in human-use services. These losses and gains can be an important part of a NRDA. Thus, reliable measures of losses and gains are essential. Economic principles provide a sound conceptual basis for evaluating such losses and gains.

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71. *See* NOAA GUIDANCE DOCUMENT, *supra* note 29, at D-1 to D-3.