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Natural resource protection on buffer lands: integrating resource evaluation and economics

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Abstract

Environmental managers are faced with the wise management, sustainability, and stewardship of their land for natural resource values. This task requires the integration of ecological evaluation with economics. Using the Department of Energy (DOE) as a case study, we examine the why, who, what, where, when, and how questions about assessment and natural resource protection of buffer lands. We suggest that managers evaluate natural resources for a variety of reasons that revolve around land use, remediation/restoration, protection of natural environments, and natural resource damage assessment (NRDA). While DOE is the manager of its lands, and thus its natural resources, a range of natural resource trustees and public officials have co-responsibility. We distinguish four types of natural resource evaluations: (1) the resources themselves (to the ecosystem), (2) the value of specific resources to people (e.g. hunting/fishing/bird-watching/herbal medicines), (3) the value of ecological resources to services for communities (e.g. clean air/water), and (4) the value of the intact ecosystems (e.g. forests or estuaries). Resource evaluations should occur initially to provide information about the status of those resources, and continued evaluation is required to provide trends data. Additional natural resource evaluation is required before, during and immediately following changes in land use, and remediation or restoration. Afterwards, additional monitoring and evaluations are required to evaluate the effects of the land use change or

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the efficacy of remediation/restoration. There are a wide range of economic methods available to evaluate natural resources, but the methods chosen depend upon the nature of the resource being evaluated, the purpose of the evaluation, and the needs of the agencies, natural resource trustees, public officials, and the public. We discuss the uses, and the advantages and disadvantages of different evaluation methods for natural resources.

Keywords

Natural resource assessment; Integrating economics; Resource trustees

Introduction

The public, managers, regulators, public officials and public policy makers are increasingly interested in assessing the health and well-being of ecosystems, and ensuring that they continue to provide ecological goods and services (Leitao and Ahern 2002). Assuring healthy ecosystems is also a mandate for contaminated sites, both private and public. While some contaminated sites are small, and the contamination encompasses most or all of the site (e.g. brownfields, Powers et al. 2000; Greenberg et al. 2001a,b; Greenberg and Hollander 2006a,b), other sites have large areas with low contamination or without any contamination. Nuclear facilities, both private and public, often have buffer lands that are wild or semiwild due to the need to protect communities from risk or because the land was considered otherwise unsuitable. Further, many such sites have been located along waterways where land was once considered wasteland or was not developable because of a high water table, tidal flow, or the threat of flooding (DOE 1994a,b).

Environmental assessment and evaluation is particularly important for the Department of Energy (DOE) complex, which is very large in size and geographical distribution. The DOE has a number of nuclear facilities with large buffer lands, not only because of geography and the need to buffer their activities, but because of the need for security of the facilities from sabotage or terrorism. DOE has land in over a 100 sites in 34 states (Crowley and Ahearne 2002), and after remediation, some will retain radioactive and hazardous wastes that will remain in place indefinitely, necessitating long-term stewardship into the unforeseeable future (DOE 1999, 2000). Not only must DOE avoid harming ecological resources during remediation (Whicker et al. 2004), but it has a stewardship responsibility for its natural resources (Malone 1998). About 79% of DOE land has been undisturbed for over 50 years because it served to buffer the nuclear production facilities (DOE 2001). The DOE is one of the federal land owners with significant natural ecosystems that bear evaluation in light of ecosystem integrity, valuable and unique habitats, endangered and threatened species, and species of special concern (DOE 1994a,b; Brown 1998; Dale and Parr 1998; Burger et al. 2003, 2007). One of the difficult challenges has been how to evaluate natural resources and integrate economics for DOE sites, a bigger task than just assessing natural resources and biomonitoring (Burger 1999, 2006; Burger et al. 2004). Natural resources under the Comprehensive Environmental Response and Compensation and Liability Act (CERCLA, section 101 [16]) are defined as “land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources" and they are evaluated by natural resource trustees.

In this paper we develop a paradigm for evaluating natural resources, as well as suggesting methods for economic evaluation. Our objective was to answer a reporter's questions about ecological evaluation: who, what, when, and where. To this list, we also add how and why. The objectives of this piece are to consider why evaluate natural resources, who evaluates natural resources, what resources are there to be evaluated, when should such evaluations occur, where are the resources, and how should such resources be evaluated. It is not our intention to answer each question in detail, but rather to provide an overall framework for how to think about the evaluation of environmental resources.

Framing the issues

Why evaluate or assess natural resources?

This is perhaps the easiest question because the answer depends entirely upon the objective of the natural resource evaluation. At its simplest level, managers and the public want to know three things about natural resources: what are they, where are they, and what good (use, value) are they. More subtle questions deal with whether the resources are of local or regional importance, whether there are species of special legal concern (such as federally endangered species), and whether there are resources that provide recreational, subsistence, or other services (see below). Maintaining and protecting natural resources requires evaluating what the resources are, how they are distributed across temporal and spatial scales, and who cares about them.

Natural resources should also be evaluated to assess whether there is improvement or a decrement in well-being, and monitoring is the usual method of trends evaluation (Cairns 1990; Carignan and Villard 2001). Monitoring is especially useful for assessing the efficacy of management (Burger 2006). Such evaluation is essential to provide early warning of any adverse effects on one (or several) components of the ecosystem that predict more severe effects. Ultimately preserving ecosystem integrity is essential for overall human health.

The DOE's objectives relative to natural resources relate to development or use of ecosystems (e.g. to build more facilities, to build roads), remediation/restoration on ecosystems or adjoining habitats required by their regulators, and environmental stewardship (Malone 1998; Burger et al. 2003). While many of the DOE sites are clearly faced with cleanup of their sites, DOE now has a mandate for environmental stewardship. DOE's stewardship program (DOE Order 430.1) has the goal of achieving sustainable development through ecosystem management of its lands as valuable national resources (Malone 1998). The DOE order included integrating economic, ecological, social, and cultural factors into land use decisions.

Who evaluates natural resources?

A wide range of institutions, agencies, and public officials evaluate natural resources, as well as the public itself (Table 1). The public, through elected officials, entrusts the evaluation and protection of natural resources to resource agencies, such as state and federal fish and wildlife services or departments (for plants, fish and wildlife), National Oceanographic and Atmospheric Administration (for marine mammals, NOAA), the Environmental Protection Agency (clean air and water, uncontaminated fish and shellfish), and Tribal governments (for resources on Native American lands). Agency authority resides in laws (e.g. Endangered Species Act, Clean Water Act, Clean Air Act, Oil Pollution Act) and regulations.

While the public delegates the responsibility for resource evaluation and protection of natural resources to these agencies, non-governmental organizations (NGOs) often serve as watch-dogs to monitor agency progress and success, often resorting to legal actions to force evaluations or protection. NGOs, such as National Audubon, Nature Conservancy, and Sierra Club, monitor natural resources and alert both the public and agencies concerning lapses or problems.

Much of the data on the health and well-being of natural resources comes from university and NGO research programs aimed at understanding physiology, behavior, and status and trends of individuals, populations, communities and ecosystems. Universities and NGOs often work with, and are funded by, governmental agencies. Natural resource evaluation is thus an iterative and interactive process among many different agencies, institutions, NGOs, universities and private individuals.

While natural resource trustees, tribal governments, and public policy makers are responsible for all natural resources, the task of protection often falls to specific agencies for only part of the natural resource world (Fig. 1). To some extent the role of individual natural resource agencies in evaluating these resources is complicated by agency mandates. That is, each agency (whether it is local, state or federal, private or governmental) has a specific mandate. These mandates derive from history, but also from a need to have definable goals (and defined responsibilities) that can be reached. Thus, agencies such as NOAA, US Fish and Wildlife Service (USFWS) and state agencies are responsible for individual species and their populations, although many of these agencies are now taking an ecosystem or landscape approach. For example, in many states it is difficult to protect particular communities (e.g. frogs nesting in vernal ponds, neotropical migrants nesting in forests), and far easier to protect an individual species that is endangered or threatened. Similarly, the US Environmental Protection Agency (EPA) has responsibility for clean water and clear air (along with state agencies), but does not deal with individual species or populations. This division of responsibility, although efficient and necessary from some perspectives, does not lend itself to a holistic evaluation or protection of natural resources.

What is being evaluated?

There are at least four types of valuation that impinge on ecological resources, remediation/ restoration, natural resource damage assessment (NRDA), and stewardship, including (1) the value of the resources themselves (to the ecosystem), (2) the value of specific resources to people, (3) the value of ecological resources to services for communities, and (4) the value of the intact ecosystems (Table 1). Although these seem similar, we submit that they are not. While each type of evaluation can be done separately by biologists, managers, and economists, it is useful to consider the other types at the same time, at least briefly.

Firstly, individual species have value to the structure and function of the ecosystem (whether it is degraded, restored, or natural). For example, pine trees serve a keystone role in pine forest ecosystems, while a species of migrant bird that moves through may have a rather minimal effect on the structure and function of a pinelands. East coast salt marshes would not function without Spartina, the species that defines the ecosystem type, and on which the system depends. The role of other species is less clear, but no less important. For example, nearly all ecosystems are dependent upon pollinators, whether they be insects, birds or bats. Some plants can be pollinated by a number of species, but others are dependent on one species. Similarly, some plants depend on other species to disperse their seeds; some seeds will not germinate unless they first pass through the gut of birds. And in some cases, such the rare *Ryparosa* of tree of Australia that depends on the increasingly endangered Cassowary for digestion and dispersal (Weber and Woodrow 2004), both the tree and bird are in jeopardy. Endangered and threatened species are special cases because their dwindling numbers may seriously impair ecosystem structure and function.

Secondly, individual species have values to people. A peregrine falcon diving over New York City, a red-tailed hawk breeding in Central Park, a white-tailed deer that can be hunted in a woodland, a Striped Bass that can be caught in a river, and a baby Robin that can be photographed all have value to recreationists. These advantages accrue to individual people, but are important values for ecological resources. In the aggregate, these recreational values have important implications for local and regional economies. Some of these same species, however, have commercial value (e.g. trees to forestry, fish and shellfish to fisheries, maple trees to maple sugar producers).

Thirdly, natural resources have value for the services, such as clean water and clean air, that they can provide to all people. Natural ecosystems also provide services that are much less obvious, such as protecting low lying communities from tidal waves and floods. Coastal ecosystem buffers human communities from both natural processes (tides, storms), as well as from catastrophic events (hurricanes). These same communities serve as nurseries for fish and shellfish stocks. Woodlots provide protection from high winds and serve as wind breaks for storms and barriers to the spread of disease. These services are provided to humanity regardless of any individual’s appreciation of these services.

Fourthly, an intact, functioning ecosystem has value as a unique habitat. For example, people can recognize, appreciate, and value an old growth forest, virgin prairie, pristine pine barrens, barrier beach forests, and saltmarshes without focusing on either individual species or the services these ecosystems provide. Images of these ecosystems are captured on film and painted, and people appreciate, buy, and covet these systems in their entirety. People may never want to extract any resources or services from these systems. Merely knowing they are there is an important natural resource value. For example, much of the public outcry about the Exxon Valdez oil spill in Prince William Sound did not have to do with natural resource damages (although these were important), nor with any individual's desire to visit, fish or hunt there, but to the mere knowledge that this valuable ecosystem was soiled (existence values). Existence values were taken into account during the Exxon Valdez legal proceedings.

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These four types of natural resources (Table 1) have several interesting aspects: (1) the first type is entirely ecological, (2) the last three are human values placed on natural resources, (3) the second type (species value to individuals) relates to individual people, but not to all people, while the third (services to humanity) relates to all people, and (4) the last one relies entirely on ecological health and well-being, but is valued as an entire system by people. Different people, agencies, and organizations focus on these different types of natural resources (Table 2).

While these four types of evaluations are clearly inter-related, each can be evaluated on its own merit, and often is, depending upon the objective of the evaluation. Nongame and Endangered Species programs, as well as the US Fish and Wildlife Service, spend a great deal of time and money evaluating the status and trends of species that are endangered, threatened, or species of special concern (our type 1 evaluation). Such departments, however, also evaluate species assemblages, such as neotropical migrants, amphibians using vernal ponds, freshwater fishes, and freshwater mussels. DOE is also obligated, by federal and state laws, to assess endangered and threatened species on their lands. Some resource departments also evaluate intact ecosystems for system problems; the New Jersey Pinelands Commission evaluates the pine barrens ecosystem as a system in its own right (type four evaluation).

Fish and game departments evaluate individual species on a regular basis that are of interest to hunters and fishermen (type 2 evaluation). Whole departments with elaborate funding schemes devote considerable time and man-power to assessing population levels of game birds, mammals, and fish with the express purpose of protecting these populations so there is sufficient excess for hunting and fishing. When the excess is not sufficient for the consumptive demand, then lotteries or other methods are designed to allow extraction only up to a certain limit. Lotteries are run for black bear in New Jersey, elk in some western states, and polar bear in some northern regions (by Inuit; http://www.abc.net.av/worldtoday/content/2003/5959583.htm).

The evaluations of natural resources for ecosystem services are less clear-cut, but some are definable. Municipalities, state agencies, and the federal Environmental Protection Agency perform regular monitoring of water quality on reservoirs that provide clean drinking water. Air quality monitoring is a complex and elaborate process across the USA, and in some cities, ozone warnings are provided in newspapers, radio and television.

When should natural resources be evaluated?

For Department of Energy sites, natural resources should be evaluated at several different times, including (1) baseline, (2) periodically to establish status and trends, (3) just prior to any remediation/restoration, (4) during and immediately after remediation/restoration, and (5) periodically after remediation/restoration. Initial resource evaluation functions to assemble data on ecosystems, species assemblages, and rare and endangered species. Periodic data collection requires indicator species (or functions) to assess the status and trends of populations. Evaluations are required before, during and after remediation/restoration to understand whether the management is successful, and for what species or communities. Following remediation/restoration long-term biomonitoring is essential to assess whether ecosystems remain healthy, whether there are failures in the remedies, whether corrective actions are necessary, and to provide lessons learned for other similar remediation or restoration projects.

Where should natural resources be evaluated?

Ideally natural resource evaluations should be conducted on all DOE lands that have some degree of functioning ecosystems. Without such data, it is difficult to design effective remediation and restoration projects that result in improvement of ecological integrity and health. However, in reality, natural resource evaluations may not be completed until a specific DOE site is slated for remediation. Under these circumstances, evaluations should be performed immediately before initiation of the remediation/restoration.

Methods of evaluating and assessing natural resources

While ecologists and conservationists evaluate natural resources and their associated species in terms of structure (how many species of herbs, shrubs, trees, amphibians, birds, mammals, or how many different layers are there in the habitat), function (nutrient cycling, energy flow, predator-prey relationships), and ecosystem health (qualitative evaluation of structure and function), managers and public policy makers may require some quantitative evaluation of natural resources. Economists want to value the goods and services ecosystems provide (to people and to the ecosystem itself). They would argue that valuation is required to compare within and among ecosystems, or in the case of the DOE, among different DOE sites, and between DOE sites and surrounding habitats. Such quantification can be accomplished by numerical comparisons (e.g. change in the number of a species, change in biodiversity, change in primary productivity) or in monetary terms. There are a number of methods for economic estimations of ecological resources (Table 2).

For the DOE, DOD, and other large land owners, this represents a challenge of assigning economic values to ecological ones. CERCLA authorizes the use of a set of standard methods for assessing economic value of land for purposes of natural resource damage assessments (61 FR 64006: Code of Federal Regulations Title 43—Public Lands: Interior Subtitle A Office of the Secretary of the Interior Part II B Natural resource damage assessments subpart E Type B Procedures). While most can be relied upon to monetize damages to resources such as a single lake or defined parcel, they cannot satisfactorily capture all of the benefits provided by such a diverse resource as are found at massive DOE sites. The methodologies outlined in CERCLA work best where measurable physical damages have already occurred. As contamination has not, at least at this juncture, necessarily migrated beyond the site boundaries, some methodologies would require a substantial amount of damage scenario development to be used.

All of the options cannot be deemed appropriate for DOE and analogous sites because of the criteria upon which they operate. Some of the methods rely on existing market prices for commodities such as water. The value may be the cost of replacement or the value lost to the owner because of the contamination. Their limitation is that they do not account for non-use values. Another approach estimates value based on the assumption that people travel to use ecological resources. As perceived environmental quality decreases in a location which is well-suited to recreational and leisure activities, people will visit it less often. There are discernable costs associated with traveling to and enjoying such recreation: time, gasoline and equipment purchases are just a few. The degradation of a resource can thus be monetized. Another approach involves identifying an area, which has similar attributes to the area under study, but is perceived as having higher environmental quality. A comparison is then made between the selling prices of the homes and businesses there and those of properties with equivalent amenities in the region of interest. Because all other discrepancies have allegedly been controlled for, the marginal price variations are taken to represent the value of the difference in environmental quality. There are a number of drawbacks which make it difficult to apply this approach to large sites. It operates on the assumption that a comparable region can be identified, which is not always possible.

Contingent valuation methods are likely to be the most useful at large sites. This method is designed to establish a hypothetical market for a particular natural resource or resource service, and it can be used to determine the use values for non-market goods. It is also the only method in existence capable of monetizing non-consumptive uses and existence values and can be effective in solving the problem of non-revelation of preferences for public goods. The method's ability to capture use and non-use values is due to the fact that respondents, in general, do not make a clear mental distinction between the two, and thus both are accounted for in their responses. The process is centered around the development of a survey instrument to elicit responses related to willingness to pay for environmental quality. For example, respondents can be presented with a scenario, and asked to respond to specific questions (Table 3). Through analysis of the data produced, it is possible to value the resource in question, usually through calculation of the mean willingness to pay.

We suggest that the DOE, natural resource damage committees, and other stakeholders face a major challenge in fitting this set of tools to the complexity of the DOE’s sites. We expect that specific problems on small sites can be monetized with a single method, but that multiple methods are likely to be needed on the large complex DOE sites, such as the Savannah River Site, Hanford, or Idaho National Laboratory that have multiple habitats.

Conclusions

The public, public policy-makers, agencies, and other organizations clearly need to assess and evaluate the health and well-being of natural resources. To perform such evaluations it is essential to first define the reason for evaluation, distinguish different types of resources, and understand who is responsible for these evaluations. We propose that evaluators clearly distinguish the different types of resources so that appropriate attention and methods can be devoted to each. This will help the public and others understand the breadth of the evaluation problem and refine the evaluation objectives, leading to better evaluation of natural resources. Appropriate assessment of natural resources requires distinguishing these categories.

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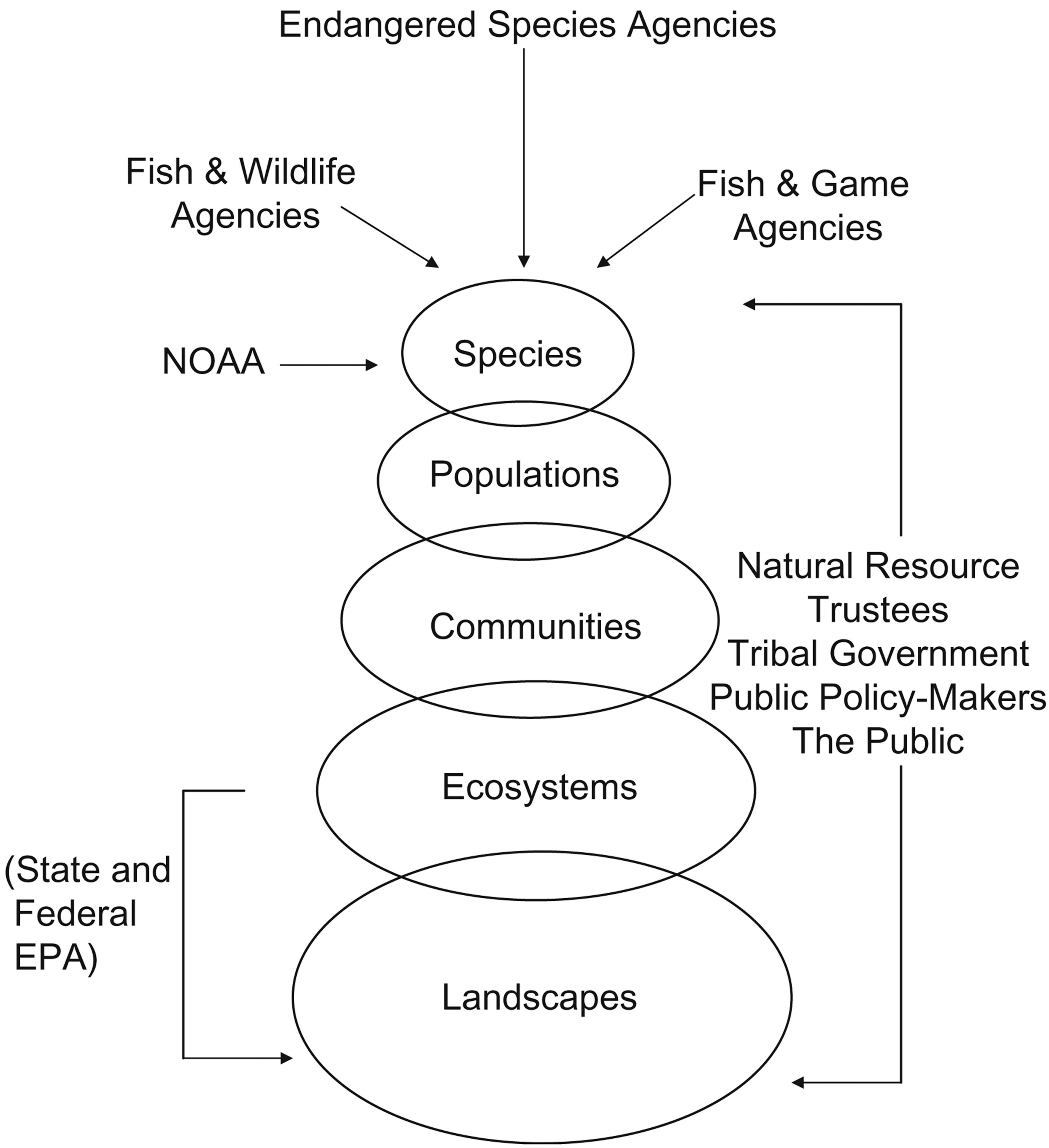

Fig. 1.

Levels of biological organization requiring assessment and evaluation, with appropriate agency involvement

Table 1

Types of resources to be evaluated, definitions, examples, and who evaluates them

Type	Definition	Examples	Evaluators
1. Resources themselves	Value of individual species to the ecosystem	Keystone species	Natural resource trustees
		Trophic role	Conservationists
		Predator/prey dynamics	Regulators
		Endangered and threatened species	Tribal councils
2. Specific resources for individuals	Value of individual species to individual people or groups of people	Fish for fishing	Fish and game agencies
		Game for hunting	Conservationists
		Birds for bird-watching	Businesses catering to recreationists
		Wildlife for photography	Tribal councils
		Fish and coral for divers	Scientists and social scientists
		Plants for religious or medicinal purposes	
3. Resources for communities	Value of ecosystem to human communities	Clean water and air	Regulators
		Buffers from storms, hurricanes.	Public policy-makers
			Coastal zone managers/Army Corp of Engineers
			Tribal councils
			Scientists
4. Intact ecosystems	Ecological, aesthetic and existence values to people	Old growth forest	Environmental Protection agencies (state and federal)
		Salt marshes	Ecologists
		Tropical forests	NGOs
		Deserts	Tribal councils
			Scientists

The examples and list of evaluators are not meant to be exhaustive, but representative.

Table 2

Suggested economic estimation methods

Type	Methods
1. Resources themselves	Use survey of selected businesses to estimate direct economic value of key species of birds, animals, trees, dunes, etc. to sightseers, tour organizers, and organizers of special events
2. Specific resources for individuals	Use sample surveys to estimate direct economic value of hunting, fishing, sightseeing, hotels, food, automobile rental to commercial businesses, and test against estimates provided by local and state officials and chambers of commerce. Estimate direct, indirect, and induced economic value, to local and regional economies using regional economic models (input-output, econometric, REMI)
3. Resources for communities	Estimate replacement value of water resources, insurance costs for protecting housing and community facilities, and a range of costs for damage associated with floods and other hazard events that could strike these facilities. Repeat analysis of direct, indirect, and induced economic values
4. Intact ecosystems	Use contingent valuation to estimate existence values. Compare results with steps 1–3 above. Repeat analysis of direct, indirect and induced economic values, after attempting to eliminate any double counting

Table 3

Sample contingent valuation questions from a larger survey about value of the local site as a preserve to nearby residents

Scenario:				
One possibility for the site, with or without expansion of nuclear-related activities, is to convert a large section into an ecological preserve. The federal government is willing to do this. However, they are unwilling to spend all the resources required by the plan developed by the community. Another option is for the federal government to give the land to the state. The state is willing to implement the plan favored by the community organization.				
1. At present, state government officials estimate that the program will cost your household a total of $300 a year. If the program cost your household a total of $300 a year would you vote for the program or against it?				
	For	Against	Not sure	Refusal to answer
2. What if the final cost of estimates show that the program would cost your household a total of $500 a year. Would you vote for or against the program?				
	For	Against	Not sure	Refusal to answer
3. What if the final cost of estimates show that the program would cost your household a total of $100 a year. Would you vote for or against the program?				
	For	Against	Not sure	Refusal to answer
4. If you voted against the program was it because you can't afford it, because it isn't worth that much money to you or because of some other reason? (please explain)				
5. And if you voted for the program, what was it about the program that made you willing to pay something for it? (please explain)				

These are sample questions from a much larger survey that would include probes about risk perception, organizational trust, values regarding the components of the environment that are most important to the respondent, and demographic characteristics.