Published in final edited form as:
Risk Anal. 2008 October ; 28(5): 1261–1272. doi:10.1111/j.1539-6924.2008.01093.x.

Ecocultural Attributes: Evaluating Ecological Degradation in Terms of Ecological Goods and Services Versus Subsistence and Tribal Values

Joanna Burger[1,2,3,*], **Michael Gochfeld**[2,3,4], **Karen Pletnikoff**[5], **Ronald Snigaroff**[6], **Daniel Snigaroff**[7], and **Tim Stamm**[7]

[1]Division of Life Sciences, Rutgers University, Piscataway, NJ, USA

[2]Consortium for Risk Evaluation with Stakeholder Participation (CRESP), Piscataway, NJ, USA and Vanderbilt University, Nashville, TN, USA

[3]Environmental and Occupational Health Sciences Institute (EOHSI), Piscataway, NJ, USA

[4]Environmental and Occupational Medicine, UMDNJ-Robert Wood Johnson Medical School, Piscataway, NJ, USA

[5]Aleutian Pribilof Island Association, Anchorage, AK, USA

[6]Atka Island, Aleutian Islands, AK, USA

[7]Nikolski Island, Aleutian Islands, AK, USA

Abstract

It is becoming increasingly clear that scientists, managers, lawyers, public policymakers, and the public must decide how to value what is provided by, and is a consequence of, natural resources. While "Western" scientists have clear definitions for the goods and services that ecosystems provide, we contend that these categories do not encompass the full totality of the values provided by natural resources. Partly the confusion results from a limited view of natural resources derived from the need to monetize the value of ecosystems and their component parts. Partly it derives from the "Western" way of separating natural resources from cultural resources or values, and partly it derives from the false dichotomy of assuming that ecosystems are natural, and anything constructed by man is not natural. In this article, we explore the previous assumptions, and suggest that because cultural resources often derive from, and indeed require, intact and unspoiled natural ecosystems or settings, that these values are rightly part of natural resources. The distinction is not trivial because of the current emphasis on cleaning up chemically and radiologically contaminated sites, on restoration of damaged ecosystems, on natural resource damage assessments, and on long-term stewardship goals. All of these processes depend upon defining natural resources appropriately. Several laws, regulations, and protocols depend upon natural resource trustees to protect natural resources on trust lands, which could lead to the circular definition that natural resources are those resources that the trustees feel they are responsible for. Where subsistence or

[*]Address correspondence to: Joanna Burger, Division of Life Sciences, Rutgers University, 604 Allison Road, Piscataway, NJ, 08854-8082, USA; tel: 732 445 4318; fax: 732 445 5870; burger@biology.rutgers.edu.

tribal peoples are involved, the definition of natural resources should be broadened to include those ecocultural attributes that are dependent upon, and have incorporated, natural resources. For example, a traditional hunting and fishing ground is less valued by subsistence peoples if it is despoiled by contamination or physical ecosystem degradation; an Indian sacred ground is tarnished if the surrounding natural environment is degraded; a traditional homeland is less valued if the land itself is contaminated. Our argument is that intact natural resources are essential elements of many cultural resources, and this aspect requires and demands adequate consideration (and may therefore require compensation).

Keywords

Aleuts; Department of Energy; ecocultural attributes; ecological goods and services; remediation; restoration; subsistence values; tribal values

1. INTRODUCTION

Increasingly, federal and state governments, tribal nations, scientists, managers, the private sector, and the public are interested in restoring degraded ecosystems, including natural resources, and in the wise stewardship of these systems. Stewardship normally refers to the long-term wise use and protection of natural or other resources, although others advocate preservation of "wilderness."[(1)] Restoring damaged ecosystems entails understanding the various ways that ecosystem have been degraded, and identifying the aspects of those ecosystems that have been injured and can be made whole or replaced. Many managers, scientists, conservationists, and others have devoted time, energy, and money to restoring ecosystems, while others have practiced stewardship of their lands and resources without restoration.

The decline in populations of wildlife is often one of the first signs of degradation, and has been dealt with legally, by the creation and enforcement of the Endangered Species Act and by the protection of land and habitat. Once a species is federally listed as endangered or threatened, the U.S. Fish & Wildlife Service designates a Recovery Team (committee of experts) to develop and implement a recovery plan, which is essentially a restoration document. Declining water quality and air quality have similarly been dealt with by federal acts that require the government to protect water and air quality. The Oil Pollution Act (OPA) specifically deals with oil spills. Under the Comprehensive Environmental Response and Compensation and Liability Act (CER-CLA) natural resource damages are assessed for injuries incurred since 1980 due to releases, but the release itself may have occurred before 1980. Most states have similar, or more stringent, laws and regulations to protect endangered and threatened species, air and water quality, or ecosystem damage from chemicals. Other laws and regulations protect other aspects of ecosystems. All of these laws and regulations are aimed at preventing further degradation and allowing ecosystems to recover, if not directly in restoration (which we view as an active process).

Before restoration can occur, there is a need to evaluate what has been degraded, and such evaluations may encompass studies at the individual, population, community, ecosystem, and landscape level. Natural resource damage assessment (NRDA) is one of the mechanisms

for this evaluation; natural resources are often evaluated in terms of the goods and services they provide. In this article, we explore the relationship between what is often called the "Western view" of goods and services, and some aspects of the views held by subsistence and tribal peoples about what nature and natural resources provide. We suggest that because cultural resources often derive from, and indeed require, intact and unspoiled natural ecosystems or settings, that these values are rightly part of natural resources. The distinction is not trivial because of the current emphasis on cleaning up chemically and radiologically contaminated sites, on restoration of damaged ecosystems, on natural resource damage assessments, and on long-term stewardship goals.[2,3] All of these processes depend upon defining natural resources, and there is a growing awareness that conventional assessments do not address all of the attributes that are "at risk" in communities.[4,5] Although several authors have examined "Tribal" versus "Western" approaches with respect to risk perception and risk assessment,[6–8] little attention has been devoted to the same dichotomy with respect to environmental assessment or valuation of what natural resources (or ecosystems) provide. In this article, we use the Department of Energy (DOE) lands as a case study, focusing on Amchitka Island where the United States conducted three underground nuclear tests from 1965 to 1971. Amchitka Island, located in the Aleutian Islands of Alaska, was a traditional home of the Aleuts, who still live on other nearby Aleutian Islands.

2. BACKGROUND ON NATURAL RESOURCE DAMAGE ASSESSMENT

One of the reasons to evaluate the "goods and services" that ecosystems provide is for either remediation or restoration, or for a more formal process of NRDA. The federal government has uniform procedures for assessing economic losses and injuries (called Natural Resource Damage Assessment) developed by the U.S. Department of the Interior (DOI) for CERCLA, and the U.S. Department of Commerce for OPA.[9] Many NRDAs have been conducted under the OPA of 1990,[10] and the Clean Water Act.[11] Natural resource damages may be recovered by federal and state trustees, and by tribal governments for injury to natural resources caused by contamination releases after 1980.[12] DOE is in the unique position of being both a trustee and a responsible party, while tribal nations and other agencies, such as DOI, are only natural resource trustees. In this article, we refer to tribal nations as those that are recognized by treaties, by federal or state agencies, or by previous legal designations. While the field of green political thought clearly acknowledges a worldview that nature is participatory, that the earth has intrinsic value, that science should be value-based, and that there is an inherent right of nature to exist,[5] we suggest that these values (shared by tribal nations and subsistence peoples) should be applied in environmental management decisions and in NRDA.

An injury to a natural resource is a measurable adverse change in the chemical or physical quality, quantity, or viability of that resource, and damages are normally assessed on the basis of loss or reduction in quantity and quality of natural resource services, to the extent that these can be monetized.[13] Assessing resource damages is a complex task that includes examining natural resources with respect to species, habitats, and ecosystem functioning, and at several levels of ecological complexity. Documentation of injuries usually involves field observations and data collection, although laboratory-generated models to predict injury to biological systems have been developed.[14–16] Documenting injuries, however,

should also include degradation to resources that require natural intact systems for their full value (such as sacred grounds or other valued landscapes), and this is more fully explored below. Several authors have noted that Native Americans are more at risk than most U.S. populations.[6,8,17,18]

3. ECOLOGICAL GOODS AND SERVICES

Many ecologists devote their careers to understanding the structure and function of ecosystems, as well as the life histories, physiology, and behavior of the species that make up these ecosystems. Biological assessment of damage and degradation is difficult because of response time variations among species and ecosystems.[19] Molecular and cellular responses may occur within minutes or days, while population changes may take years, and ecosystem changes may not be evident for decades. Death of individuals may take only days to weeks, while changes in productivity and food webs may be apparent only decades after the chemical release.

When ecologists evaluate ecosystem degradation, they usually focus on how the structure and function of the ecosystem itself has been degraded, and not on the services these systems provide specifically (and exclusively) to people. Formal NRDA, however, has forced ecologists to place ecosystem degradation in structure and function within a framework of the goods and services these systems provide to people. During the mid 1990s some authors emphasized the significance of natural capital as a precondition for societal development,[20,21] which led to ecological economics and the evaluation of the capacity of ecosystems to sustain human well-being.[22] Ecological economics has developed as a discipline to develop and test methods of valuation, and government agencies have convened forums to provide some uniformity in such methods.[23] There are several methods for economic valuation of natural resources,[24,25] but these methods are not the main focus of this article, which aims instead to broaden the categories considered when assessing natural resources (see below). Although ecological economics is extremely useful in developing economic models for valuation of ecosystems (and their goods and services),[26] in a way this field channeled ecological evaluation away from some of the less quantifiable, ephemeral, aesthetic, and holistic values of ecosystems.

A first step for assessing degradation is to provide a list of the goods and services that ecosystems provide (Table I). Degradation to each of these is then evaluated, often difficult because degradation requires a baseline or reference point. A baseline can either be established by examining conditions before degradation occurred, or by comparison to a reference site where degradation has not occurred.

For most practical purposes, ecological goods usually refer to extractable organisms or products, such as herbs (for gardens, medicine, or ceremonies), trees (for lumber), and fish and game (for food) (Table I). The value of pharmaceuticals derived from plants is sometimes used as a surrogate for the value of the plants themselves,[27] without necessarily including cultural values and herbalism. Services usually refer to positive aspects that ecosystems provide, such as clean air or water, protection against storms or high tides, or scenic views for enjoyment or photography, assuming that aesthetics translates into tourism

dollars. In some cases, scientists contrast subsistence use with commercial use, but this dichotomy is also false in many cases[28] because the same resource may be used for both subsistence and commercial use by different groups of people, or even by the same people (for example, the Aleuts use halibut as a subsistence food, but some also participate in a wholly owned Aleut fishery). Recently, ecologists and economists have added existence values to the services ecosystems provide. Existence value refers to the pleasure people derive from simply knowing that an ecosystem exists (even if they derive no direct goods or services from that system),[29–31] and reflects a willingness to pay some amount to preserve that unused existence.

4. SUBSISTENCE AND TRIBAL ECOCULTURAL ATTRIBUTES

Cultural risk and impact occur as a result of environmental contamination or degradation due to impaired quality of the resource, ecological harm or lost environmental functions and services, ramifications of health risk, avoidance or restrictions on access or use (for ecological or cultural resources), ecological harm, or social and cultural ramifications of the costs of responses, replacement, avoidance, restrictions, or restoration.[6] Although subsistence and tribal peoples clearly derive the same goods and services from natural resources as do others, they also derive additional values from intact ecosystems that may be less obvious within other cultures (although we will argue that similar values exist in all cultures, but Western scientists have usually chosen to ignore them in NRDA considerations). One interpretation is that what may be an “existence value” for some remote population is actual aesthetic appreciation for populations close at hand. While subsistence needs and tribal needs are not always the same, there are some commonalities. We use subsistence to refer to those people who derive a significant proportion of their food and other tangible resources from nature (noncommercial sources), and tribal as referring to Native American Indian groups, who may or may not derive a significant proportion of their food from the land. Including the Alaska Native village corporations, there are nearly 600 recognized American Indian tribal groups in the United States.[32]

We suggest that while most economists and other Western scientists value the goods and services that ecosystems provide, subsistence and tribal peoples often have a broader, more holistic view of the interrelationship of natural and cultural resources (see Fig. 1). A healthy ecosystem is one that supports its natural plants and animals, as well as sustaining the biophysical, cultural, and spiritual health of native peoples.[6,33–38] There are two distinctions that bear comment: (1) people who view natural resources holistically (i.e., subsistence and tribal peoples) often combine many of the traditional goods and services together rather than considering them separately (for example, people go fishing and hunting, visit burial or sacred grounds, and camp while doing so), and (2) many resources considered to be cultural by Western scientists have a natural resource base as an integral part (for example, a sacred ground includes not only any manmade or altered structures, but the physical environment and natural resources surrounding it; Fig. 1).

Viewing cultural resources in this manner requires both a paradigm shift and a new terminology, and we suggest that the term ecocultural attributes is appropriate. Harris and Harper[6] coined the term ecocultural dependency webs to reflect the values and perspectives

of tribal communities, and they proposed using ecocultural webs in risk assessment. We believe that ecocultural attributes is an appropriate term for the interdependencies that subsistence and tribal peoples place on the cultural resources that have a necessary natural resource component.

The recognition that tribal peoples can make significant and seminal contributions to the intellectual discourse surrounding conservation, management, restoration, and long-term stewardship is gaining strength (see tribal risk assessments noted above). As Posey[39] noted, recognition of the contribution of indigenous and traditional people to science requires a reversal of the global trends that substitute economic and utilitarian models for the holistic concept of the "sacred balance." Similarly, we propose that the more traditional "Western" view of valuation of natural resources (for whatever purposes) should be broadened to include the values of subsistence and tribal peoples.

Finally, we have drawn a distinction between a "Western" view of the goods and services ecosystems provide (for the purposes of valuation), and the subsistence and tribal ecocultural values discussed above, but we recognize that these categories are neither discrete, nor exclusive. That is, some "Western" scientists take a more holistic view of natural resources (and include some ecocultural attributes), and some tribal peoples concentrate on the extractive goods and services ecosystems provide. Further, the green movement embodies some of the same concepts and advocates radical social change.[5] We note, however, that these tribal values are not unlike some of the secular or social community aspects that apply to suburban communities.[6] Further, we suggest that the view that the sum of the parts is indeed greater than the whole is likely shared by many cultures (perhaps all), but that the "Western mind" is rarely asked about these values. It may well be the value of nontraditional aspects of ecosystems are not recognized because they are rarely asked about. We draw the distinction only to make the point that valuation of natural resources should include those cultural resources that derive from, and indeed require, intact and unspoiled natural ecosystems or settings. These ecocultural attributes are an integral part of natural resources, and should be included in environmental assessments, remediation and restoration plans, and NRDA.

5. DOE AND THE CASE OF AMCHITKA ISLAND

The DOE is responsible for over 100 sites in 34 states that comprise the Department of Energy's "Nuclear Weapons Complex."[40] Some of these lands, appropriated in the 1940s and 1950s for the nuclear mission, were traditional or ceded tribal lands. That is, Indian Treaties of the 1850s and 1860s acknowledged the sovereign government of individual tribes, the creation of reservations (for some tribes), and the rights of tribes to pasture livestock and to take fish and wildlife at all the "usual and accustomed" places, both inside and outside their reservations.[41] At Hanford in Washington, the Yakama Indian Nation, the Umatilla Tribe, the Wanapum, and the Nez Perce Tribe ceded land near the Columbia River for DOE activities, but the tribes retained rights to hunt and fish, gather roots and berries, and to pasture horses and cattle on open and unclaimed land.[42–44] Other large DOE sites were also built on lands that were traditional American Indian hunting and fishing grounds, including the Shoshone-Bannock on Idaho National Laboratory, and the San Ildefonso

Pueblo, Jemez Pueblo, Santa Clara Pueblo, and Cochiti Pueblo at what is now the Los Alamos National Laboratory.[45–48]

Amchitka Island (51°N lat, 179°E long) was one of the islands traditionally inhabited by the Unangan people (Aleuts), although there was not an active community there prior to the development of a World War II military base, or the decision to test nuclear weapons. Although it is 280 km to the nearest active Aleut community on Adak Island, the Aleuts consider the whole Aleutian Chain their home.[25] Amchitka was the site of three underground nuclear tests (1965–1971) by the Atomic Energy Commission (AEC) and Energy Research and Development Administration (ERDA), predecessors of the Department of Energy (DOE). Responsibility for its cleanup rested with the National Nuclear Security Administration (NNSA) division of DOE, while the U.S. Fish & Wildlife Service (USFWS) has landowner responsibility for Amchitka Island, which is part of the Alaska Maritime National Wildlife Refuge.

In the 1960s, there was considerable controversy about nuclear testing at Amchitka, including the potential health risks to humans, particularly the local Aleuts, the serious damage to the marine ecosystem, and the possible generation of tsunami activity.[49,50] The releases of radiation to the surface during the tests were not considered to pose serious health risks at the time,[51,52] partly because most of the radioactive material was probably spontaneously vitrified when the intense heat of the underground blasts melted the surrounding rock.[53] Recent controversy reflects continued public concern about the possibility of subsurface transport of radionuclides from the three cavities to the marine environment in light of the region being one of the most seismically active and dynamic subduction zones on earth.[54] A primary concern was and is whether the subsistence foods of the Aleuts, as well as the commercial fish and shellfish from the island vicinity, were safe to eat.[17,55] Many Aleuts live in small villages on remote islands, and are absolutely dependent upon locally derived plants and animals; they are thus both tribal and subsistence peoples.

DOE addressed the Aleut concerns by providing a draft groundwater model and human health risk assessment, which showed that there was very little potential risk.[53,56] However, many stakeholders, including the Aleuts, had little faith in the groundwater models, and less faith in the human health risk assessments, largely because there were no site-specific data on either consumption patterns or radionuclide levels in subsistence foods, and ecological characterization of the marine environment was ignored or misrepresented. Further, Aleuts sometimes fish near Amchitka Island for halibut.

The DOE, State of Alaska (ADEC), U.S. Fish & Wildlife Service (USFWS), the Aleut Pribilof Islands (APIA), and other stakeholders disagreed about the path forward to DOE's closure of Amchitka Island. By closure DOE meant that it needed no further action for remediation, and that it would not need to monitor the Amchitka environment in the future. The Consortium for Risk Evaluation with Stakeholder Participation (CRESP) was asked by the DOE to develop a comprehensive Science Plan, in conjunction with ADEC, USFWS, APIA, and DOE, that would provide the science basis for closure.[16,57] CRESP is an independent, multiuniversity, consortium consisting of environmental, biological, and social

scientists, risk assessors, and public policy analysts that had been working together for nearly 10 years to address environmental and risk problems faced by the DOE. The execution of the Science Plan, data analyses, and report writing were mainly the responsibility of the CRESP science team, interacting with, integrating ideas and concerns from, and collaborating with a range of stakeholders during each phase. A team from the APIA accompanied the scientists on the expedition to Amchitka to provide information on subsistence foods and to collect in their traditional manner.[57] The radionuclide data from the samples of algae, invertebrates, fish, and birds collected at Amchitka indicated that there was no current risk, but CRESP recommended that biomonitoring be part of the long-term stewardship plan for Amchitka because of the potential for leakage.[3,18,58,59]

Following the expedition to Amchitka to collect samples, radionuclide analysis, and report writing, CRESP continued the dialogue with stakeholders in meetings in Anchorage, Homer, and the Aleut villages of Atka, Nikolski, and Unalaska. CRESP was seeking advice about future biomonitoring and continued concerns about Amchitka. Questions and comments mainly related to the information provided about radionuclides and their levels in biota, possible risk from radionuclides, future monitoring to assure subsistence food safety,[25,60,61] and an overwhelming concern about mercury (which we ultimately analyzed, see Burger *et al.*,)[17] and its effects.

However, the Aleuts, publicly and privately, voiced concerns about many other effects besides just the radionuclide levels in subsistence foods. The concerns expressed by Aleuts in public meetings held in their villages included: the health and well-being of a range of plants, invertebrates, fish and marine mammals, top predators in the system, the overall well-being of the marine environment around Amchitka, degradation of the marine environment in general, degradation of the island surface itself (which impacted the value of their burial ground there), degradation of the island itself as a potential future home or village site, degradation of past villages (now only archeological or potential archeological sites), and a general unease with the spoiling of one of their otherwise pristine homelands (see asterisk (*) in Table I). In other words, their concerns were not just for ecological goods and services, nor even for mere existence values, but for the despoiling of the land and marine environment with its animals, land, ancient campsites and villages, and burial grounds that require intact natural resources and ecosystems. They repeatedly mentioned that they had to live in harmony with nature and depended upon it on a daily basis, an observation also made for other Native American tribes.[62,63] Tribes such as the Apache see links between ecological, social, and personal dimensions;[64] they are not healthy if the ecosystem is not healthy. In a survey of several hundred Native American tribes, Weaver and White[65] reported that one commonality was that native people’s values are deeply rooted in the land of their origin. These observations suggest that for any environmental cleanup or restoration, and if natural resource damages are assessed and compensated, ecocultural attributes should be included because each requires intact and nondegraded natural resources. This contrasts with Western urbanites and suburbanites who are isolated from (and sometimes fearful of) the land and its wildlife.

At Amchitka, the surface environment has been cleaned up, but currently there are no technologies that can remove contamination in the nuclear test cavities. Thus, it is not a case

of using natural resource evaluation for the purposes of deciding how to clean it up, but rather of determining if there is a need for biomonitoring to assure that the subsistence foods continue to be safe, and if so, how and when should biomonitoring occur.[55]\

Several DOE sites are adjacent to rivers where subsistence fishing plays an important role in the lives of people, for food, recreation, and a number of other cultural values that require intact natural resources. For example, the Columbia River runs through Hanford, the Savannah River runs through the Savannah River Site, the Clinch River runs adjacent to Oak Ridge Reservation, and the Peconic River runs through Brookhaven National Laboratory, among others. In each of these cases, there are fishermen who depend upon the river for fish. The people using the rivers who are at risk varies. At Oak Ridge, the most exposed group are mainly wealthy, suburban fisherfolk,[66] those who are most exposed at Savannah River Site are primarily low-income African Americans,[67] and those who use the Columbia River are primarily Native Americans.[6,68] In these cases, and for many other subsistence fishermen, the fish that the rivers provide is only part of the experience of fishing.[69]

6. MELDING ECOLOGICAL GOODS AND SERVICES WITH ECOCULTURAL ATTRIBUTES

For remediation, restoration, natural resource damage assessment, and long-term stewardship to move forward it is essential to form a more holistic view of the ecocultural attributes that ecosystems and their component parts provide. While in the above sections the dichotomy between the two views was clearly drawn, we recognize that there is indeed a continuum between these two views, and that many state and federal agencies have tried to meld the two. We suggest that a true melding of the two views, however, will occur only when the “Western view” is broadened to encompass the subsistence and tribal viewpoints (see the addition of the ecocultural attributes in Table I). Humans and their artifacts (including sacred grounds or monuments) are just as much a part of nature as any other organism.[71] Ecosystem management is not just about science or resource management paradigms,[71,72] but may require reframing environmental values to move forward.[22] However, melding traditional goods and services with ecocultural attributes is not just about social justice in an ecology eutopia,[5] but rather recognizing the solution of environmental management problems; the two must be melded in practice as well as in theory.

The difficulty with melding the econometric evaluation of goods and services with ecocultural values is finding a common metric. Perhaps rather than using purely economic values (as is done with evaluating goods and services), we should develop indices of values that assign values on a scale (e.g., 1–10) for different goods, services, and ecocultural traits. This would have the advantage of including all types of values that ecosystems provide. This process is accepted for evaluation of the perceptions and concerns of people,[72] and could be employed similarly for ecological goods, services, and ecocultural attributes.

Humans are clearly components of ecosystems, and as such have natural resource requirements in a manner similar to other species;[73] we can no longer afford to pretend that people can be separated from natural resources. We maintain that the natural resource base for cultural and religious aspects of communities is an integral part of natural resource

evaluation, whether for management, remediation and restoration, NRDA, or long-term stewardship. In 1854, Chief Seattle of the Suquamish Tribe wrote a letter to President Franklin Pierce, noting that "all things are connected" (cited in Reagan[73]) and it is this connectedness that ties cultural and social resources to natural resources, and suggests the use of ecocultural attributes as one component of ecosystem evaluation (along with the more traditional goods and services).

7. CONCLUSIONS

In this article, we note the disconnect between what is often called a "Western" view of the goods and services provided by ecosystems and the more holistic view often held by subsistence and tribal peoples. While the former includes existence value as an ecological service, it misses the point that it could encompass the subsistence/tribal holistic view of ecocultural attributes, which include many other values in addition to the goods and services normally attributed to ecosystems (see Fig. 1). We note that human wellness is a culmination of many inputs, including those unproved but common sense feelings of pervasive environmental degradation and the dread of future unknown effects. Multiple unknown, uncontrollable stressors lead to greater feelings of unease and powerlessness than do controllable single stressors. Perhaps all cultures see the intrinsic value of their surroundings as intact, and recognize the multiple losses even if they accept the losses more rapidly, or if scientists fail to ask about them.

We are proposing that for the purposes of environmental assessment, remediation and restoration, NRDA, and long-term stewardship, evaluation of ecological degradation include three categories, goods, services, and ecocultural attributes. Each is dependent upon aspects of ecosystem structure and function. The degradation or decline of any plants, animals, and other aspects of ecosystems diminishes the relative value of each of these three (goods, services, or ecocultural attributes). For ecosystems to be sustainable, they must fill the needs of all organisms within that system, including subsistence and tribal peoples. Moreover, cultural capital, including both tangible (sacred or monumental buildings, gardens, works of art) and intangible forms (practices, beliefs, myths, stories, traditions, aesthetic value)[74] is often dependent upon, and an integral part of, natural resources.

This approach will have the added advantage of bringing together a wider range of tribal nations and stakeholders to address and solve environmental problems, resulting in decisions that are more collaborative, cost and time effective, and harmonious. Further, it has the advantage of being proactive, rather than reactive,[72] as is the usual approach to environmental management, and of fitting within the American Indian culture of partnerships and reciprocity.[75]

Acknowledgments

We particularly thank C. W. Powers, M. Greenberg, M. Duchesne, D. Ehrenfeld, and R. B. Stewart for helpful discussions about natural resource values. Our thinking about the ecological goods and services, tribal and subsistence values, ecological risk, and natural resource damage assessment has been influenced by R. Patrick, B. D. Goldstein, J. Clark, S. Handel, B. Harper, S. Harris, and D. Kosson. We thank S. Shukla for help with the graphics. This research was partly funded by the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) through the Department of Energy (AI # DE-FG 26-00NT 40938 and DE-FC01-06EW07053), by NIEHS P30ES005022, EPA, and New Jersey Endangered and NonGame Species Program. The conclusions and

interpretations reported herein are the sole responsibility of the authors, and should not in any way be interpreted as representing the views of the funding agencies.

References

1. Norton BG. Seeking common ground for environmental change. Forum Applied Research in Public Policy. 1995; 11:100–102.
2. Burger J, Leschine TM, Greenberg M, Karr J, Gochfeld M, Powers CW. Shifting priorities at the Department of Energy's bomb factories: Protecting human and ecological health. Environmental Management. 2003; 31:157–167. [PubMed: 12520373]
3. Burger J, Tsipoura N, Gochfeld M, Greenberg M. Ecological considerations for evaluating current risk and designing long-term stewardship on Department of Energy lands. Long-term Management of Contaminated Sites, Research in Social Problems and Public Policy. 2007; 13:141–164.
4. Frohmberg E, Goble R, Sanchez V, Quigley D. The assessment of radiation exposures in Native American communities from nuclear weapons testing in Nevada. Risk Analysis. 2000; 20:101–111. [PubMed: 10795343]
5. Kassman, K. Envisioning Ecotopia: The US Green Movement and the Politics of Radical Social Change. Westport, CT: Praeger; 1997.
6. Harris SG, Harper BL. A Native American exposure scenario. Risk Analysis. 1997; 17:789–795. [PubMed: 9463932]
7. Zender, LS.; Gilbreath, S.; Sebalo, S.; Leeman, W.; Erbeck, A. [Accessed on September 5, 2007] How Much Does Tradition Matter: Comparison of Tribal Versus Non-Tribal Values in the Context of Waste Site Pollution. 2004. Available at http//www.zender-engr.net
8. Bridgen P. Protecting Native Americans through the risk assessment process: A commentary on "An examination of U.S. EPA risk assessment principles and practices. Integrated Environmental Assessment and Management. 2005; 1:83–85. [PubMed: 16637152]
9. Ofiara DD. Natural resource damage assessments in the United States: Rules and procedures for compensation from spills of hazardous substances and oil in waterways under US jurisdiction. Marine Pollution Bulletin. 2002; 44:96–110. [PubMed: 11981983]
10. Austin SA. The National Oceanic and Atmospheric Administration's proposed rules for natural resource damage assessment under the Oil Pollution Act. Harvard Environmental Law Review. 1994; 18:549–562.
11. Sheehy DJ, Vik SF. Natural resource damage claims: Potential DOD liabilities and mitigation opportunities. Federal Facilities Environmental Journal. 2003; 14:17–28.
12. Trimmier, R., Jr; Smith, JB. The scope of natural resource damage liability under CERCLA. In: Stewart, RB., editor. Natural Resource Damages: A Legal, Economic, and Policy Analysis. Washington, DC: National Legal Center for the Public Interest; 1995. p. 9-30.
13. Department of Energy (DOE). Natural Resource Damages Under CERCLA. Washington, DC: USDOE; 1993. EH-231-017/0693
14. Grigalunas TA, Opaluch JJ, French D, Reed M, Dnauss D. A natural resource damage assessment model for coastal and marine environments. Geology Journal. 1988; 16:315–321.
15. Higley KA, Domoto SL, Antonio EJ. A probabilistic approach to obtaining limiting estimates of radionuclide concentration in biota. Journal of Environmental Radioactivity. 2003; 66:75–87. [PubMed: 12590071]
16. Higley KA, Domoto SL, Antonio EJ. A kinetic-allometric approach to predicting tissue radionuclide concentrations for biota. Journal of Environmental Radioactivity. 2003; 66:61–74. [PubMed: 12590070]
17. Burger J, Gochfeld M, Jeitner C, Burke S, Stamm T, Snigaroff R, Snigaroff D, Patrick R, Weston J. Mercury levels and potential risk from subsistence foods from the Aleutians. Science of the Total Environment. 2007; 384:93–105. [PubMed: 17590413]
18. Burger J, Gochfeld M, Powers CW, Kosson DS, Halverson J, Siekaniec G, Morkill A, Patrick R, Duffy LK. Scientific research, stakeholders, and policy: Continuing dialogue during research on radionuclides on Amchitka Island, Alaska. Environmental Management. 2007; 85:232–244.

19. Barnthouse LW, Stahl RG Jr. Quantifying natural resource injuries and ecological service reductions: Challenges and opportunities. Environmental Management. 2002; 30:1–12. [PubMed: 12053235]
20. Costanza R, Daly HE. Natural capital and sustainable development. Conservation Biology. 1992; 6:37–46.
21. Costanza R, d'Arge R, deGroot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P, Van Den Belt M. The value of the world's ecosystem services and natural capital. Nature. 1997; 387:253–260.
22. Folke C. The economic perspective: Conservation against development versus conservation for development. Conservation Biology. 2006; 20:686–688. [PubMed: 16909555]
23. Bingham G, Bishop R, Brody M, Bromley D, Clark EE, Cooper W, Costanza R, Hale T, Hayden G, Kellert S, Norgaard R, Norton B, Payne J, Russell C, Suter G. Issues in ecosystems valuation: Improving information for decision making. Ecological Economics. 1995; 14:73–90.
24. Soderqvist T, Eggert H, Olsson B, Soutukorva A. Economic valuation for sustainable development in the Swedish coastal zone. Ambio. 2005; 34:169–175. [PubMed: 15865316]
25. Burger J, Gochfeld M, Greenberg M. Natural resource protection of buffer lands: Integrating resource evaluation and economics. Environmental Monitoring and Assessment. 2008; 142:1–9. [PubMed: 17899418]
26. Bockstael N, Costanza R, Strand I, Boynton W, Bell K, Wainger L. Ecological economic modeling and valuation of ecosystems. Ecological Economics. 1995; 14:143–159.
27. Suneetha MS, Chandrakanth MG. Establishing a multi-stakeholder value index in medicinal plants: An exonomic study on selected plants in Kerala and Tamilnadu States of India. Ecological Economics. 2006; 60:36–48.
28. Madhusudan MD. The global village: Linkages between international coffee markets and grazing by livestock in a South Indian wildlife reserve. Conservation Biology. 2004; 19:411–420.
29. Brookshire DS, Eubanks LS, Randall A. Estimating option prices, and existence values for wildlife resources. Land Economics. 1983; 59:1–15.
30. Larson DM. On measuring existence value. Land Economic. 1993; 69:177–188.
31. Johansson-Stenman O. The importance of ethics in environmental economics with a focus on existence values. Environmental Research Economic. 1998; 11:429–442.
32. Stubben JD. Working with and conducting research among American Indian families. American Behavior Science. 2001; 44:1466–1481.
33. Whalen S. The Nez Perces' relationship to their land. Indian Historian. 1971; 4:30–33.
34. Jacobs, WR. Indians as ecologists and other environmental themes in American frontier history. In: Vecsey, C.; Venables, RW., editors. American Indian Environments: Ecological Issues in Native American History. Syracuse, NY: Syracuse University Press; 1980. p. 46-64.
35. Stoffle RW, Evans JJ. Holistic conservation and cultural triage: American Indian perspectives on cultural resources. Human Organization. 1990; 49:91–99.
36. Tano ML, Reuben JH, Powaukee D, Lester AD. An Indian tribal view of the back end of the nuclear fuel cycle: Historical and cultural lessons. Radwaste. 1996; 3:44–47.
37. Cajete, G. A People's Ecology. Santa Fe, NM: Clear Light Publishers; 1999.
38. Stumpff LM. Reweaving the earth: An indigenous perspective on restoration planning and the National Environmental Policy Act. Environmental Practice. 2006; 8:93–103.
39. Posey DA. Commodification of the sacred through intellectual property rights. Journal of Ethnopharmacology. 2002; 83:3–12. [PubMed: 12413701]
40. Crowley KD, Ahearne JF. Managing the environmental legacy of U.S. nuclear-weapons production. American Scientist. 2002; 90:514–523.
41. Nez Perce Tribe. Treaties: Nez Perce Perspectives. Richland, WA/Lewiston, ID: US DOE and Confluence Press; 2003.
42. Schuster, HH. Yakima and neighboring groups. In: Walker, JE., editor. Handbook of North American Indians: Vol. 9. Southwest. Washington, DC: Smithsonian Institution Press; 1998. p. 327-351.

43. Stern, T. Cayuse, Umatilla, and Walla Walla. In: Walker, JE., editor. Handbook of North American Indians: Vol. 9. Southwest. Washington, DC: Smithsonian Institution Press; 1998. p. 395-419.
44. Gephart, RE. Hanford: A Conversation About Nuclear Waste and Cleanup. Richland, WA: Batelle Press; 2003.
45. Arnon, NS.; Hill, WW. Santa Clara Pueblo. In: Ortiz, A., editor. Handbook of North American Indians: Vol. 9. Southwest. Washington, DC: Smithsonian Institution Press; 1979. p. 296-307.
46. Edelman, SA. San Ildefonso Pueblo. In: Ortiz, A., editor. Handbook of North American Indians: Vol. 9. Southwest. Washington, DC: Smithsonian Institution Press; 1979. p. 308-316.
47. Lange, CH. Cochiti Pueblo. In: Ortiz, A., editor. Handbook of North American Indians: Vol. 9. Southwest. Washington, DC: Smithsonian Institution Press; 1979. p. 366-372.
48. Sando, JS. Jemez Pueblo. In: Ortiz, A., editor. Handbook of North American Indians: Vol. 9. Southwest. Washington, DC: Smithsonian Institution Press; 1979. p. 418-424.
49. Greenpeace. Nuclear Flashback: The Return to Amchitka. Anchorage, AK: Greenpeace, USA; 1996.
50. Kohlhoff, DW. Amchitka and the Bomb: Nuclear Testing in Alaska. Seattle, WA: University of Washington Press; 2002.
51. Seymour, AH.; Nelson, VA. Radionuclides in air, water, and biota. In: Merritt, ML.; Fuller, RG., editors. The Environment of Amchitka Island, Alaska. Washington, DC: Technical Information Center, Energy Research and Development Administration; 1977. p. 579-613.(Report TID-26712)
52. Faller, SH.; Farmer, DE. Long-Term Hydrological Monitoring Program: Amchitka, Alaska. Washington, DC: U.S. Environmental Protection Agency; 1998. (EPA-402-R-98-002)
53. Department of Energy (DOE): DRAFT. Modeling Groundwater Flow and Transport of Radionuclides at Amchitka Island's Underground Nuclear Tests: Milrow, Long Shot, and Cannikan. Nevada Operations Office; Las Vegas, NV: 2002. DOE/NV-11508-51
54. Eichelberger JC, Freymueller J, Hill G, Patrick M. Nuclear stewardship: Lessons from a not-so-remote island. Geotimes. 2002; 47:20–23.
55. Burger J, Mayer H, Greenberg M, Powers CW, Volz CD, Gochfeld M. Conceptual site models as a tool in evaluating ecological health: The case of the Department of Energy's Amchitka Island nuclear test site. Journal of Toxicology and Environmental Health. 2006; 69:1217–1238. [PubMed: 16754537]
56. Department of Energy (DOE): DRAFT. Draft Screening Risk Assessment for Possible Radionuclides in the Amchitka Marine Environment. Nevada Operations Office; Las Vegas, NV: 2002. DOE/NV-857
57. Burger J, Gochfeld M, Kosson D, Powers CW, Friedlander B, Eichelberger D, Barnes D, Duffy LK, Jewett S, Volz CD. Science, policy, and stakeholders: Developing a consensus science plan for Amchitka Island, Aleutians, Alaska. Environmental Management. 2005; 35:557–568. [PubMed: 15886955]
58. Powers, CW.; Burger, J.; Kosson, D.; Gochfeld, M.; Barnes, D., editors. Biological and Geophysical Aspects of Potential Radionuclide Exposure in the Amchitka Marine Environment. Piscataway, NJ: CRESP; 2005.
59. Burger, J.; Gochfeld, M.; Kosson, DS.; Powers, CW. Biomonitoring for Ecosystem and Human Health Protection at Amchitka Island. Piscataway, NJ: CRESP; 2006.
60. Burger J, Gochfeld M. Changes in Aleut concerns following the stakeholder-driven Amchitka independent science assessment. Risk Analysis. (In press).
61. Burger J, Gochfeld M, Kosson D, Powers CW, Friedlander B, Stabin M, Favret D, Jewett S, Snigaroff D, Snigaroff R, Stamm T, Weston J, Jeitner C, Volz C. Radionuclides in marine fishes and birds from A-chitka and Kiska Islands in the Aleutians: Establishing a baseline. Health Physics. 2007c; 92:265–279. [PubMed: 17293699]
62. Coggins K, Williams E, Radin N. The traditional tribal values of Ojibwa parents and the school performance of their children: An exploratory study. Journal of Amercian Indian Education. 1997; 36:1–12.
63. Pewewardy C. Learning styles of American Indian/ Alaska native students. Journal of Amercian Indian Education. 2002; 41:22–56.

64. Long J, Tecle A, Burnette B. Cultural foundations for ecological restoration on the White Mountain Apache Reservation. Conservation Ecology. 2003; 8:4–16.

65. Weaver HJ, White BJ. The Native American family circle: Roots of resiliency. Journal of Family Social Work. 1997; 2:67–79.

66. Campbell KR, Dickey RJ, Sexton R, Burger J. Fishing along the Clinch River arm of Watts Bar Reservoir adjacent to the Oak Ridge Reservation, Tennessee: Behavior, knowledge, and risk perception. Science of the Total Environment. 2002; 299:145–161. [PubMed: 12462581]

67. Burger J, Gaines KF, Gochfeld M. Ethnic differences in risk from mercury among Savannah River fishermen. Risk Analysis. 2001; 21:533–544. [PubMed: 11572431]

68. Harris SG, Harper BL. Using eco-cultural dependency webs in risk assessment and characterization of risks to tribal health and cultures. Environmental Science and Pollution Research. 2000; 2:91–100.

69. Burger J. Fish consumption advisories: Knowledge, compliance, and why people fish in an urban estuary. Journal of Risk Research. 2004; 7:463–479.

70. Davidson, EA. You Can't Eat GNP: Economics as if Ecology Mattered. Cambridge, MA: Perserus; 2000.

71. Grumbine RE. What is ecosystem management. Conservation Biology. 1994; 10:328–337.

72. Likert R. A technique for the measurement of attitudes. Archives of Psychology. 1932; 140:1–55.

73. Reagan DP. An ecological basis for integrated environmental management. Human and Ecological Risk Assessment. 2006; 12:819–833.

74. Throsby D. Culture, economics and sustainability. Journal of Cultural Economics. 1995; 19:199–206.

75. LaFrance J. Culturally competent evaluation in Indian country. New Directions for Evaluation. 2004 Summer;:39–50.

76. Burger J. Consumption patterns and why people fish. Environmental Research. 2002; 90:125–135. [PubMed: 12483803]

77. de Groot RS, Wilson MA, Boumans RMJ. A typology for the classification, description, and valuation of ecosystem functions, goods, and services. Ecological Economics. 2002; 41:393–408.

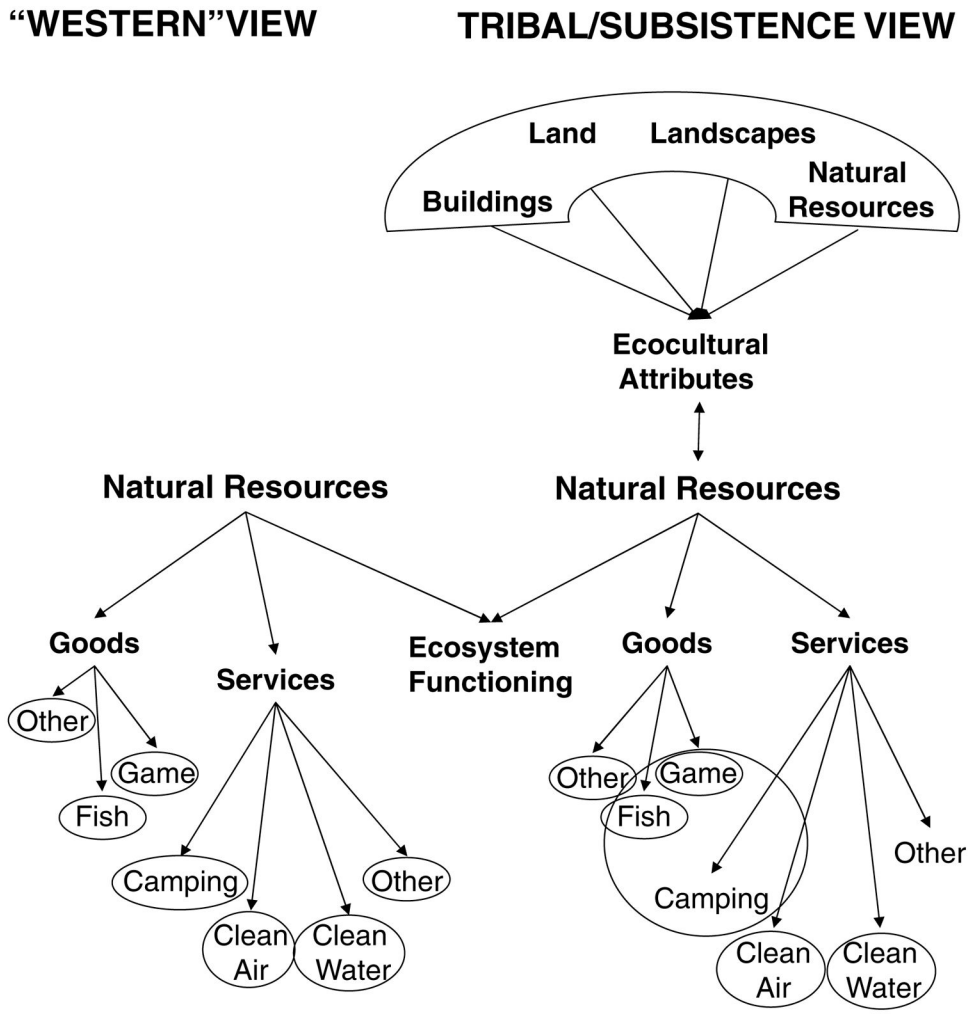

Fig. 1.

Schematic of a "Western" view of what is provided by natural resources, and a subsistence and tribal view.

Table I

A Partial List of Goods and Services Ecosystems Provide as Commonly Viewed by Western Scientists (Developed from Bingham *et al.*,[23] Harris & Harper,[6] Costanza *et al.*,[21] Burger,[76]; deGroot *et al.*,[77] Folke, [22] Reagan,[73]), and Those Proposed for Ecocultural Values

Goods	Services	Ecocultural Attributes
*Fish for fishing	*Clean air	*Clean and functioning habitats as components of cultural and social sacred grounds or monuments
*Game for hunting (including marine mammals in case of the Aleuts)	*Clean water	Intact ecosystems, free of noise and disturbances for cultural and social sacred grounds or monuments
*Herbs for medicine or religious activities	Buffers for coast lands against storms and hurricanes	*Plants, rocks, or animal parts for tools, clothing, or shelter
Plants for gardens	Trees for windbreaks against strong winds	**Clean and functioning ecosystem so that Native Americans could reoccupy their traditional homelands or fishing/hunting grounds at some point in the future[a]
Wood for lumber	Bees and other insects for pollinators	
*Fruits and nuts for consumption	Interesting plants, wildlife, scenes, or other aspects for photography, tourism, ecotourism, resorts	Soil sufficiently clean that it can be used in facial markings, body paints, and ceramics
Sap for maple sugar	Clear water and terrestrial environments for recreation	Game for ceremonies (such as rattlesnakes for the Hopi rattlesnake dance)
Fish and algae for fish aquariums	Bats, birds, and other animals for seed dispersal	*Free from the fear that fish and game are contaminated, that ceremonial, burial, or other sacred grounds are contaminated and have lost value because of degradation
Soil, gravel, rocks, or other materials for roads, gardens, or other construction	Climate regulation	
Plants for grazing livestock	Soil formation and erosion control	
Plants for pharmaceuticals	Biological control of pests Reservoir for biological diversity Existence values	

Note: Existence values as part of ecosystem services is separated from the other services because it begins to approach the ecocultural values component of environmental assessment that we are proposing. An asterisk (*) means it is important to the Aleuts as expressed in public and private meetings in their villages and in Anchorage.