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Stewardship and the US Department of Energy: Encompassing Ecosystem Protection

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ABSTRACT *Stewardship normally refers to the long-term wise use and protection of natural or other resources. In the last 5 years the US Department of Energy (USDOE) has included stewardship as an important mission. Although the USDOE documents include responsibility for the protection of natural environments, statements on stewardship refer to responsibility for the long-term protection of human health and the environment from radioactivity and hazardous chemicals. We suggest that the USDOE should incorporate the buffer land around its hazardous sites into its stewardship mission, by adding these considerations to its Office of Environmental Restoration and developing performance measures for stewardship of this land that are as rigorously pursued as its clean-up goals. Although there will be lost opportunity costs, this option will have the advantages of ecosystem protection and enhanced ecosystem integrity, in addition to continued monitoring, assessment and security.*

Introduction

The environmental movement has suffered from a dichotomy of world views: some advocate preservation of 'wilderness' while others propose conservation and wise use of natural resources (Norton, 1995). The conflict resulting from these two views is partly a function of scale. Sustainable exploitation of natural resources is not problematic as long as there is other land nearby that is not exploited. With increasing exploitation of small parcels, the overall landscape has fewer and fewer large parcels of undisturbed and wild land (Hardin, 1968; Burger & Gochfeld, 1998). Continued exploitation of natural resources has led to the continued degradation and fragmentation of habitat (Cairns, 1995). Two decades ago Leopold (1979) argued that we should err on the side of caution and reduce the number of ecological changes we make in our environment. This is particularly true, given the complexity of the relationships between biodiversity and ecosystem structure and function (Risser, 1994). While any ecosystem management may be viewed as egocentric (Ehrenfeld, 1981), there are policies

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that more clearly protect functioning ecosystems (Stanley, 1994), and slow the loss of biodiversity world-wide (Brussard, 1991).

The dichotomy that is apparent in the environmental movement is equally visible in the stewardship mission of some federal agencies, such as the US Department of Energy (USDOE). While some may argue that the land should be maintained for preservation's sake, or to maintain viable security buffers, others argue for its conservation or wise use. The latter goal would entail examining the areas surrounding USDOE land to determine the relative importance of USDOE land within a regional or landscape context. How important is this land to the surrounding region? If it is critical, consideration should be given to its maintenance as a functioning ecosystem. With Landsat images, such analyses are now possible on a landscape scale, and determining the importance of this land is an important first step.

Over the last 50 years the USDOE has acquired large landholdings in 34 US states. For the purposes of security and to prevent human exposure, some of these sites were surrounded by extensive buffer areas from which humans were excluded. The land has different degrees of contamination, and is in different stages of remediation (DOE, 1995a, b). It is potentially very costly to clean up such sites, and the degree of clean-up depends partly upon future land uses (National Research Council (NRC), 1995; USDOE, 1996a, b, c; Grumbly, 1996). Clean-up, or environmental restoration, usually refers to the contaminated land and facilities (USDOE 1996a, b), and not to the larger buffer areas that are not contaminated. At some of the large USDOE sites, 80–90% of the land is largely uncontaminated. Moreover, reclaiming contaminated land is a general problem world-wide as countries manage and clean up military land remaining from the Cold War or other local wars.

Some areas on USDOE sites are so highly contaminated that remediation with current technologies is not feasible, and such sites are destined for long-term storage of nuclear and chemical waste. When land cannot be cleaned up, it becomes part of a long-term stewardship mission of the USDOE, which includes reducing the risks to humans and ecosystems from hazardous wastes (USDOE, 1996a, b) through maintenance of security and prevention of off-site migration. Vast areas on some of the large USDOE sites served as security and contamination buffers. However, since the buffer areas are not contaminated, and require neither clean-up nor human exclusion, the USDOE has not considered this land worthy of stewardship. Incorporation of this land under the USDOE mission of stewardship could preserve these intact ecosystems for future generations (Mann *et al*., 1996; Brown, 1998). Such incorporation, however, is a policy decision.

Ecologists are best suited to aiding in the maintenance of healthy ecosystems, and they must learn to work within the socio-political context (Moran, 1994) if they are to influence policy. This includes understanding the processes that lead to actions, and identifying which can be changed by laws, regulations and institutional procedures (see Costanza, 1993). While policy decisions are often science-based, there must also be a clear link between government science and regulatory process (Babbitt, 1995). Ecological risk assessment is emerging as one method for evaluating the effect of stressors on ecological systems (Bilyard *et al*., 1993; NRC, 1993), and has been successful partly because the uniform methods have been developed by federal agencies (Norton *et al*., 1992), and have been adopted by a number of bureaux and agencies (Lackey, 1994). A similar

approach for USDOE lands would facilitate wise stewardship, and provide a paradigm for other federal agencies that manage land.

In this paper we examine the meaning of stewardship for the USDOE, contrast this meaning with the usage of the term by ecologists, conservationists and the general public, summarize survey results that indicate the ecological and recreational importance of this land and explore ways in which the stewardship mission of the USDOE can be broadened to protect some of its valuable ecosystems. We suggest that one way to influence future land use, including the preservation of intact ecosystems, is to have the USDOE broaden its definition of environmental restoration and stewardship to include its vast array of buffer land surrounding its hazardous facilities, rather than only the contaminated sites themselves, and to protect these ecosystems intact. This requires expanding the USDOE's definition of stewardship, from remediation, clean-up and future containment of hazardous industrial facilities and sites, to include stewardship of the surrounding intact ecosystems (USDOE, 1996c). We suggest that adding buffer zones as part of the current USDOE stewardship mission would have several advantages, with few additional costs. Advantages include: (1) preserving ecological habitats that are intact and functioning and, in some cases, critical and unique in the general region; (2) reducing the level of clean-up required in buffer land; (3) preserving the buffer to reduce human exposure, and increase human health and safety; and (4) preserving a buffer for monitoring and assessment, as well as security. The increased costs are minimal, although there are lost opportunity costs in terms of the use of this land for other economic interests.

At the outset it is critical to understand the different meanings of stewardship to place the USDOE's stewardship mission within a broader context. The main meanings of stewardship seem to fall into two categories: those that deal with natural and cultural resources; and those that relate to the legacy from the Cold War (Table 1; see also Lowrie & Greenberg 2000).

Stewardship and the USDOE Mission

The USDOE and its predecessors operated nuclear reactors and processing facilities at a number of sites from the 1940s, while other sites assembled weapons and used nuclear material for the development of technologies and research (USDOE, 1999a). The USA was left with a vast quantity of hazardous waste, the legacy of the Cold War. With the ending of the Cold War, the USDOE is under considerable pressure to dispose of the nuclear wastes safely, without harm to humans or the environment. The remediation and clean-up are monumental because the USDOE has some 3700 sites in 34 states. The USDOE estimates that it represents 20% of the world's environmental remediation tasks (Sink & Frank, 1996). The USDOE is responsible for most of the USA's radioactive materials that require disposal—over 2×10^6 m^3 of radioactive wastes—including high-level, low-level, mixed, transuranic and other types (USDOE, 1999a). The USDOE oversees 30 000 tonnes of commercial nuclear power plant spent fuel, the single largest concentration of radioactivity in the world (USDOE, 1999a). Of the 11 largest USDOE sites, Hanford Site, Savannah River Site (SRS) and Idaho National Engineering and Environmental Laboratory (INEEL) have the majority of high-level waste (Consortium for Risk Evaluation with Stakeholder Participation, 1999). Stabilization, remediation and clean-up are required

Table 1. Representative definitions of stewardship to show the range of meanings; while many other sources, groups and agencies could be cited, this presents the range of definitions

Agency or group	Definition	Source
Orthodox Christian Archdiocese	Caring for the needs of one another.	Nicola (1982)
US Environmental Protection Agency Monitoring Conference	The exercise of responsible care over possessions entrusted to a steward. A long-term commitment to a river, wetland or other natural resource.	US Environmental Protection Agency (1997), Kimball (1997)
NRC	The care and attention that contaminated areas will receive after clean-up is 'complete'.	NRC (2000)
President's Council on Sustainable Development	An ethic of stewardship builds on collaborative approaches to ecosystem integrity, and incentives in such areas as agricultural resources, management, sustainable forestry, fisheries, restoration and biodiversity conservation.	President's Council on Sustainable Development (2001)
American Fisheries Society	Sound stewardship is the state in which resources, and the ecosystem that supports them, are managed in such a way way that their long-term viability and productivity are maintained for the benefit of future generations.	American Fisheries Society (2001)
Forestry Service	Caring for the land and serving people by listening to all constituents and living within the limits of the land.	Dombeck (1997)
US Department of Defense	The faithful management of resources as assets which must be turned over to the next generation.	US Department of Defense (2001)
USDOE	Includes all activities that occur at sites after closure, including long-term surveillance and maintenance, institutional controls and long-term funding.	Stewart (2001)
USDOE	Reducing long-term risk to humans and ecosystems from hazardous wastes.	USDOE (1994a, 1999a)
USDOE	Includes all activities required to protect human health and the environment from hazards remaining at USDOE sites after clean-up is complete.	USDOE (1999b)
State and Tribal Government Working Group	Must ensure long-term protection of human health, the environment and cultural resources.	National Council of State Legislatures (1999)

Table 2. Principles of ecosystem management to achieve sustainable development (after USDOE, 1994b; Malone, 1998)

- Include humans within the ecosystem, including their dependence on ecosystems.
- Require partnerships and co-operation between federal, state and local governments to manage land sustainably.
- Involve stakeholders in joint decision making.
- Use an interdisciplinary approach to socio-economic and ecological goals of stakeholders.
- Base management on ecological regions, not jurisdictional boundaries.
- Recognize the limits of ecological knowledge, and practise adaptive management (modify policies as new information is available).

before the USDOE can fully concentrate on its current primary mission of energy development and research (NRC, 1995).

In the post-Cold War era, the USDOE developed new objectives, including those of environmental management, disclosure of information to the public, the redefinition of use strategies for its facilities and buffer areas and, finally, recognition of its "responsibility to act as a steward of national resources" (USDOE, 1996a, p. 7). This led directly to the formation of an Office of Environmental Management, the initiation of future land use discussions and the development of stewardship programmes (USDOE, 1994b; 1996a; 1999a, c; Sink & Frank, 1996).

The formal stewardship programme of the USDOE was initiated in USDOE order 430.1 in 1996 with a directive to achieve sustainable development through ecosystem management. This order states that it is the USDOE's policy to manage its land and facilities as valuable national resources, and to integrate mission, economic, ecological, social and cultural factors in a comprehensive plan for each site that will guide land and facility decisions (USDOE, 1994b, 1996a; Malone, 1998). Stewardship initiatives ranged from the small (improve the recycling of paper and decrease the use of disposable materials) to the large scale (perpetual security for permanent nuclear waste disposal and containment).

The emphasis on stewardship affected both environmental management and future land use, leading ultimately to future land use committees and recommendations for some USDOE sites (USDOE, 1996a). Although the defining statements for ecosystem management involved ecological principles (Table 2), these were not always incorporated into the environmental restoration procedures (USDOE, 1994a; 1999a, c), even though there are federal policies for managing natural resources on federal land (Interagency Ecosystem Management Task Force, 1995–96).

In 1989 the USDOE established the Office of Environmental Management to deal with the remediation task on its facilities, and to develop new technologies that would reduce risk to humans and ecosystems (Sink & Frank, 1996; Daisey, 1998). Developing technologies for environmental clean-up emerged as one of the USDOE's top missions, and by 1995 the Office of Environmental Management's budget for technology development was nearly US$800 million.

The USDOE defines the primary mission of its Office of Environmental Restoration as maintaining and improving human health and safety, and protecting the environment (USDOE, 1994b). This involves eliminating or reducing risks posed by inactive and surplus facilities. This task involves a number of

activities, such as site discovery, preliminary assessment, site inspection, site characterization, analysis of clean-up alternatives, the selection of remedies, clean-up and site closure, and site compliance and monitoring (USDOE, 1994a). The USDOE began implementing a 'cradle to grave' approach to the management of hazardous wastes, although by 1994 most environmental restoration projects had not gone beyond the assessment phase (USDOE, 1994a). Thus there is still an opportunity to influence environmental restoration and stewardship, including a broadening of the overall goals, particularly with reference to protecting the environment.

An important aspect of the USDOE's concept of stewardship involves life-cycle management, within the context of the larger region and with stakeholder participation (USDOE, 1994b; O'Leary, 1997). This refers to the determination of the costs of any process or action from its inception until the end of the life of those products or breakdown products. There has been considerable progress in the Office of Environmental Restoration, including the establishment of performance measures (USDOE, 1999c), and in future land use discussions with stakeholders (NRC, 1994, 1995; USDOE, 1996a), but relatively little about stewardship, either nationally or at individual sites (except for the Nevada Test Site (Malone, 1998) and Oak Ridge Reservation (USDOE, 1998a)).

In its evaluation of the USDOE's environmental management programme, the NRC (1995, p. 11) noted that "responsible stewardship means undertaking appropriate near-term or mid-term action to remediate a site to protect the public and the environment". The NRC (1995) further notes that stewardship can allow progress even though no permanent solution is available. Its concept of stewardship within the context of the USDOE involves containment (preventing any transport or movement of hazards) and risk reduction for both humans and ecosystems, and is not a final solution.

Both the definition of stewardship used by the USDOE and that accepted by the NRC (DOE, 1994a; NRC, 1995) include mainly hazardous waste sites and hazardous buildings, and do not address the vast areas of buffer land created around the hazardous facilities. We propose that the USDOE should broaden its definition to include stewardship of these valuable buffer land, discussed briefly below.

Even within the context of stewardship, defined as reducing long-term risk from hazardous wastes to humans and ecosystems, the USDOE's Office of Environmental Restoration barely mentions stewardship (USDOE, 1994a, 1999a). However, clean-up and environmental restoration are key components of the mission statements for Hanford Site, INEEL, Rocky Flats Environmental Technology Site and Oak Ridge Reservation, but are not listed under the mission statement for Los Alamos National Laboratory (LANL) (USDOE, 1994a). This is partly because LANL is a laboratory with a variety of ongoing research programmes and defence missions.

Two of the USDOE's sites that are taking the stewardship mission seriously are the Nevada Test Site and Oak Ridge Reservation. Nevada Test Site is taking steps to implement the USDOE's stewardship policy by applying the ecosystem management initiative to its facilities and future land uses (Malone, 1998). The stewardship mission includes integrating resource management in the goals of its programme (Table 3). Nevada Test Site's goals included the sustainability of land resources to sustain ecosystems and native biota, and to protect undisturbed ecological areas (Malone, 1998). One of its first tasks was to make an

Table 3. Goals adopted by Oak Ridge Reservation for stewardship of radioactive and chemical wastes that could be usefully applied to stewardship of intact ecosystems on their buffer land (after USDOE, 1998a)

• Identify essential elements of effective stewardship.
• Develop long-term stewardship requirements.
• Identify options for long-term funding for stewardship.
• Promote public understanding of stewardship.
• Promote interactions between individuals and governments regarding stewardship.

inventory of ecological resources, with the aim of protection. While an inventory alone is not sufficient for stewardship, understanding the resources that are present is a necessary first step. Thus, the Nevada Test Site encompasses ecological resources as part of its stewardship programme.

Oak Ridge Reservation has developed a *Stakeholder Report on Stewardship*, which it hopes will serve as a model for other USDOE facilities (USDOE, 1998a). However, it limits its stewardship to maintaining "long-term protection of human health and of the environment from hazards posed by residual radioactivity and chemically hazardous materials" (USDOE, 1998a, p. 1). The definition is the narrower one used by the USDOE, and not the more general definition of wise and responsible use of natural resources that agencies such as the National Park Service and the US Fish and Wildlife Service use.

The USDOE's Valuable and Uncontaminated Buffer Land

When the USDOE and the US Department of Defense established their nuclear weapons complexes following the Second World War, they purchased buffer land around them for security reasons, and to reduce the potential for human exposure (Mann *et al.*, 1996). Risks to humans from radioactivity were reduced by preventing access to the wide buffer land which was largely untouched by USDOE activities. In some cases, this land encompasses hundreds of square miles. Military activities and industrialization, with accompanying radiological and chemical wastes, were usually restricted to a small and central section on each site, leaving the rest relatively undisturbed for up to 50 years (Mann *et al.*, 1996).

The ecological importance of USDOE lands was recognized in the 1970s and 1980s, when Congress designated some USDOE sites as National Environmental Research Parks (NERPs) to develop methods for evaluating the consequences of human actions related to energy and weapons use, to explore methods to minimize the adverse effects of energy and weapons and to train people in environmental science (USDOE, 1994c). Their other missions include assessment and monitoring, prediction and public education (USDOE, 1994c).

At present there are seven NERPs. These are Fermilab, Hanford Site, INEEL, LANL, Nevada Test Site, Oak Ridge Reservation and SRS. The seven NERPs represent seven of the 15 physiographic regions of the USA: shrub steppe (INEEL and Hanford Site); desert shrub (Nevada Research Park); juniper–pinyon and grassland, and southern Rocky Mountain conifers (LANL); tall-grass prairie (Fermilab); eastern deciduous forest (Oak Ridge Reservation); and south-east

Table 4. Characteristics of the seven NERPs designated by Congress; location refers to nearest city (after USDOE 1994c, 1996a), Brown (1998), Dale & Parr (1998) and other sources listed in the table)

	Fermilab	Hanford Site	INEEL	LANL	Nevada Test Site	Oak Ridge Reservation	SRS
Location	Batavia, IL	Richland, WA	Idaho Falls, ID	Los Alamos, NM	Las Vegas, NV	Oak Ridge, TN	Aiken, SC
Size (ha)	2750	148 000	230 000	11 500	350 000	14 266	79 000
Year	1989	1978	1975	1978	1992	1980	1972
Habitat	Tall-grass prairie, oak–hickory parkland	Shrub steppe	Sagebrush steppe	Upper Sonoran, pinyon–juniper woodland, mixed conifer	Desert	Eastern deciduous forest	South-east mixed forest
Endangered species, federal	None	None	None	South-west willow flycatcher,[a] peregrine falcon	None	Peregrine falcon, Bald Eagle, cougar	Red-cockaded woodpecker, wood stork, smooth purple coneflower, short-nosed sturgeon
Threatened species, federal		Aleutian Canada goose, Bald Eagle	Bald Eagle	Mexican spotted owl, Bald Eagle	Desert tortoise		Bald Eagle, American alligator

Endangered threatened species, state	Columbia yellowcress, Northern wormwood, American white pelican, Sandhill crane	None	Wood lily, yellow lady slipper[a]	Beatleys milkvetch	Several plants and invertebrates	Star-nosed mole, South-eastern big-eared bat
Threatened species, state	Columbia milkvetch	None	New Mexico meadow jumping mouse, Jemez Mountains salamander,[a] spotted bat	Upland sandpiper, several plants	Several plants, blue sucker, Northern river otter, Northern pine snake, osprey	South-eastern myotis
Unique characteristic	Only stretch of pristine Columbia River, Native American sites	Many obligate sagebrush species	Ancient pueblo sites	Several categories of species listed as 2[b]	Oak–hickory–ash, limestone cliffs, sinkholes and barrens	Carolina bays, Longleaf-turkey oak woods, Sandhill cranes
Other sources	USDOE (1995a, 1996b), Geist (1995)	USDOE (1995b, 1996c)	USDOE (1998b), LANL (1998)	Malone (1998)	Mann *et al.* (1996), USDOE (1998a)	Dunning *et al.* (1992), Gibbons (1993), Dunning & Kilgo (2000)

[a]Occurs on land immediately adjacent to the NERP.
[b]Of special concern there.

mixed forest (SRS) (Brown, 1998). It is impressive that nearly half of these ecologically defined zones occur on the NERPs.

The NERPs have some ecologically sensitive and rare habitats (Table 4). For example, Hanford Site has the only free-flowing stretch of the Columbia River, an important spawning region for salmon, as well as natural resources valuable to the local Native American tribes (Geist, 1995; DOE, 1996b, c; Harris & Harper, 1998). Hanford Site's Arid Lands Environmental Reserve encompasses most of the remaining natural desert steppe habitat in the country. Likewise, SRS has many of the remaining Carolina Bay habitats—ephemeral ponds essential to biodiversity (Gibbons, 1993). Oak Ridge Reservation has unique habitats, including cedar barrens, river bluffs and wetlands, which are surrounded by pasture, cropland, woodlots and urban areas (Mann *et al*., 1996). Many of the sites have both endangered and threatened species, as well as rare habitats (USDOE, 1994c).

Many of the other USDOE sites could be designated as NERPs because of their unique ecosystems. For example, Brookhaven National Laboratory contains much of the remaining pristine pine barrens on Long Island, the remainder having succumbed to development over the past half-century. It would be an excellent candidate for NERP designation, and on-site personnel are exploring this option (J. Nadau, personal communication). Such a designation would connect its pine barren habitat with other small sections of pristine habitat that occur adjacent to the site.

INEEL has some of the only shrub steppe habitat in the region, which is largely undisturbed and ungrazed (USDOE, 1996c). This site can be used as an example to show how the presence of relatively undisturbed habitat is critical to the region. Most of the area surrounding INEEL is either grazing land or farmland. The region has many obligate sagebrush species that otherwise do not have a large expanse of protected land. Another important factor for INEEL, as with many of the other sites, is that it possesses significant cultural and historical resources for Native Americans (in the case of INEEL, the Shoshone–Bannock tribes of Fort Hall) (USDOE, 1996a; Burger, 1999a). Unless this land is maintained as a buffer, these valuable cultural resources will be lost, along with the ecological resources. INEEL, and other agencies responsible for land with tribal rights, is working closely with the Shoshone–Bannock tribes to allow access and to manage the cultural and ecological resources on the site (USDOE, 1996a).

This USDOE land is critical because of its large size and relative lack of human disturbance for almost 50 years. While the imprints of human activities are felt in every ecosystem (Cairns & Niederlehner, 1995), the buffer land around USDOE industrial complexes was largely undisturbed because of the necessity for national security. Even when the buffer land is not rare or threatened, it represents important landscapes because the habitat is largely unbroken and not fragmented. While the USDOE land was preserved because of security and to reduce risk to humans, surrounding communities were developing, mainly to service the sites (Frisch *et al*., 1998; Greenberg *et al*., 1998, 1999). In many cases, towns and cities abut the USDOE sites, and in others, farmland or grazing land is adjacent to these sites. While the ecological value of this USDOE land was less 50 years ago when the USDOE facilities were placed in remote, low-density landscapes, this is no longer true today, making the buffer land increasingly important ecologically as a repository of biodiversity.

The NERPs are also important to the USA because of their large size and long-term data sets. For example, the NERPs are, on average, 5 times larger than the Long-term Ecological Research Sites established by the National Science Foundation in 1979. USDOE personnel and contractors have established long-term data sets on many ecological variables (e.g. water quality and soil carbon) and a wide range of species (micro-organisms to vertebrates) at the sites. These are some of the longest-running environmental monitoring data sets in the world. The value of the NERPs for continued study is enormous, and monitoring research is essential to understand how they function and change. Originally established to study impacts on ecosystems, studies on NERPs can provide critical information on the management of contaminated and partially contaminated sites, as well as on ecosystem resilience. The maintenance and improved co-ordination of this resource should be an integral part of the USDOE's mission.

One method of evaluating whether the NERPs have been successful is to compare their mission with accomplishments. Their stated mission is to assess and monitor the environmental impact of their activities, to develop predictive tools for environmental response and to provide education (USDOE, 1994c). Their mission of assessment has been critical because these USDOE sites have some of the longest-running ecological data sets in the world (Dale & Parr, 1998). Their second mission, to develop predictive tools, has been particularly noteworthy in the areas of bio-indicator development (Burger, 1999b) and methods development (e.g. Newman & McIntosh, 1991; Bartell *et al.*, 1992; Newman & Jagoe, 1996). Finally, the NERPs have provided invaluable data about the ecological resources of the sites. While many of these data have been presented in the scientific literature (see USDOE, 1994c), the sites have produced a wealth of information for the public and managers, which includes species lists for many of the major groups of animals and plants on each site. Many of the sites have produced different brochures and booklets for the public on a variety of topics, such as endangered species (e.g. LANL, 1998).

Public Support for NERPs

Public support is essential for protecting functioning ecosystems within the context of stewardship on USDOE lands, and for maintaining the NERPs as natural ecosystems. Partly, the USDOE could enlarge its areas slated for long-term stewardship to include some of the buffer areas which are now designated as NERPs.

Since 1995 we have been engaged in understanding the recreational use and the future land use preferences of people living around SRS, INEEL and LANL. Our overall protocol was to interview people attending recreational sports (hunting, fishing and outdoor sports) and other events (festivals and races) in the local region. We specifically targeted recreationists, including hunters and anglers, so that we could both evaluate the potential risk from on-site recreation and examine the preferences of this group for future land use. Recreation is one of the future land uses the USDOE had envisioned for many of these sites (USDOE, 1996a). Although one weakness of the study is the choice of event for interviews, this is also a strength because it targets the group potentially at risk. Potential risk derives from the contamination on site and exposure (number of days on site) of individuals who might use the site.

Our protocol was to use the same trained interviewers for each survey, to ask the same questions and to select subjects by walking transects through the event, interviewing people every 2–3 m. Interviews usually required about 20 minutes, and our refusal rate was very low (less than 3%). Ethnicity varied among sites: at SRS the population was mainly white and black; at INEEL the populations were white and Native American; and at LANL the population was mainly white and Hispanic. For more details on methodology, see Burger (1997, unpublished data) and Burger *et al.* (1997, 1998, 2000).

Our surveys of public opinion around SRS, INEEL and LANL indicate that people place a high value on preserving them as NERPs (Figure 1). In nearly all of the groups we interviewed, NERPs ranked as the most preferred future land use (Burger, 1997; Burger *et al.*, 1997, 1998, 2000; Burger, unpublished data). This ranking was obtained for all ethnic groups examined. Other uses that were ranked highly included using the land for hiking, camping, hunting and fishing. All groups ranked continued or increased nuclear storage and residential uses as least preferred. In the country overall, nature reserves and wilderness are important values (Rudzitis & Johansen, 1991).

While the importance of preserving the NERPs as long-term research sites has been discussed recently in public forums, the USDOE's Office of the Inspector General recommended the disposal of nearly one-quarter of the NERP holdings (Brown, 1998). This conclusion was reached because this land seemed no longer relevant to the USDOE mission of environmental remediation, weapons dismantling, storage of nuclear material and energy development and research. Yet once lost, this land will never be recovered (Brown, 1998). The Cold War era, and the establishment of the USDOE sites for national security, will probably not occur again.

There is, however, a dislocation between the USDOE's mission of stewardship, which largely refers to being a steward over its hazardous waste sites and facilities (USDOE, 1994a, b), its avowed role as a 'steward of national resources' (USDOE, 1996a) and its lack of interest in the buffer land and in the NERPs around its hazardous facilities. This land has another advantage. For the most part, it does not require extensive remediation and ecological restoration because it already hosts functioning ecosystems (USDOE, 1994c). We suggest a broadening and redefinition of the USDOE's stewardship policy to include the buffer land and NERPs, as they represent important national resources.

Broadening the USDOE's Definition of Stewardship

As noted above, the USDOE's definition of stewardship involves remediation, and overseeing of its radiological and chemical waste sites (including buildings and other facilities) (USDOE, 1999c), but not its buffer land. This buffer land, however, has served as nature reserves or research parks for the past 50 years, and now represents some of the most valuable, intact ecosystems in its regions (Mann *et al.*, 1996; Brown, 1998).

For the establishment of most nature reserves, there are questions about the optimal size, which are resolved by addressing three issues: (1) identifying keystone or endangered species of interest; (2) determining the minimum number of individuals necessary for survival of the species; and (3) using known densities to determine the area needed to sustain the minimum number (Soule & Simberloff, 1996). While there is still considerable debate, both about this

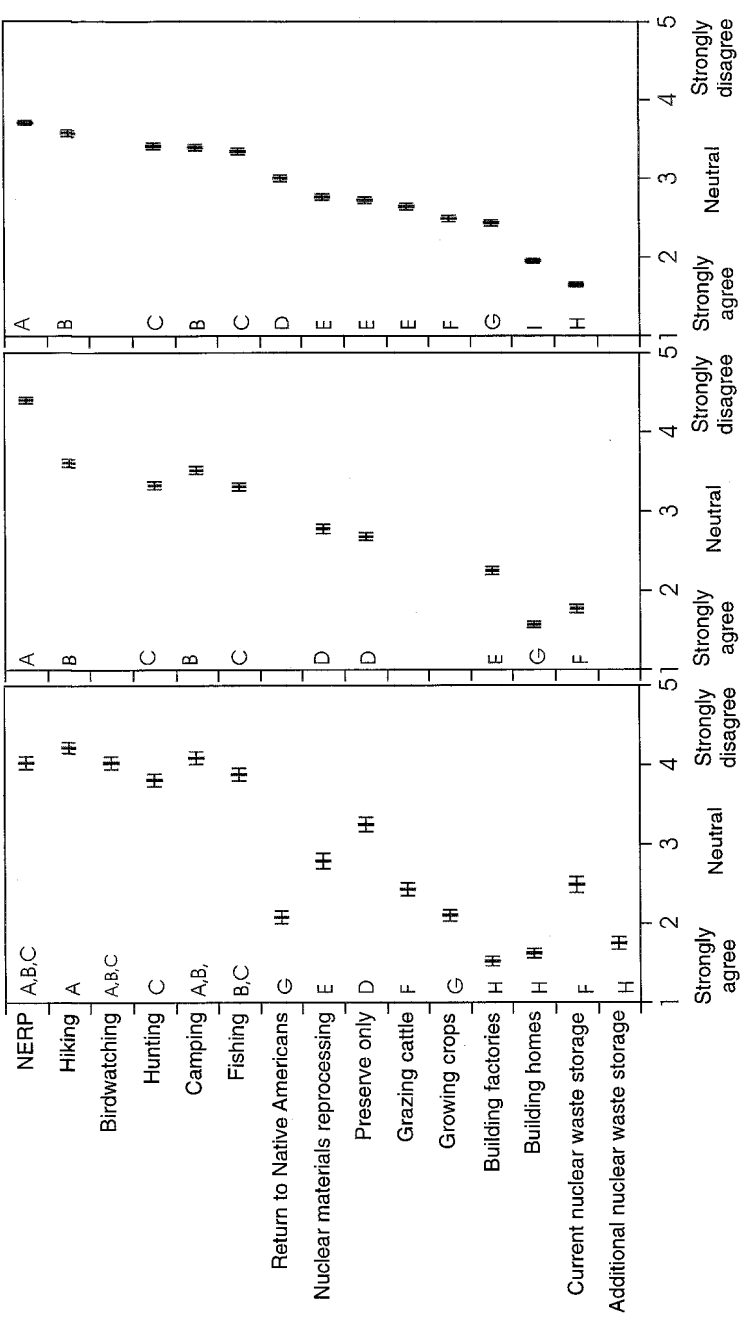

Figure 1. Relative rating (mean ± standard error) for different future land uses at LANL, SRS and INEEL.

process and about the outcomes, some procedure must be followed to decide how much land to preserve when such parcels are threatened with development, as well as how much land to restore or add to existing nature reserves. The goals are to protect endangered or key species, to preserve intact ecosystems and to maintain species diversity (Soule & Simberloff, 1996). What we have learned over the last century is that we cannot protect our natural landscape by the creation of a few isolated and fragmented small parks or nature reserves (Babbitt, 1995). Biodiversity quickly declines.

The USDOE, however, is in the enviable position of having vast quantities of land already preserved, in large NERPs and other holdings, which are relatively undisturbed (USDOE, 1994b, c). The presence of endangered species on the NERPs, which require large, intact ecosystems, demonstrates that the NERPs are sufficiently large to meet optimum size requirements (see above). Increasingly, landscape-scale processes are influencing the health and survival of a number of rare and endangered species (Dunning *et al.*, 1992), and the USDOE has the advantage of owning large enough parcels to allow landscape processes to occur intact. Furthermore, unlike most of the world (Prendergast *et al.*, 1993), the USDOE already has detailed inventories of biodiversity on the NERPs, which are available for making wise future land use decisions about these ecosystems.

Enhanced Stewardship of NERPs and Other Buffer Land

The intact, highly undisturbed and functioning ecosystems that are currently security buffers around USDOE radiological and chemical hazardous waste sites can be maintained as a valuable national resource by incorporating their stewardship into the goals and aims of the Office of Environmental Restoration. This involves a low-cost broadening of its stewardship mission to include this land. Since the USDOE is already maintaining this land as a buffer, the additional costs in adding it to its stewardship mission are negligible. However, if it was to allow some limited recreation, then the costs would increase, although there would be economic gains to the surrounding region through increased tourism and use of hotels, restaurants and other facilities (Solitare *et al.*, 2000). Further, there is a potential cost in terms of lost opportunities from the sale of this land or its use for industry or housing.

While most environmental restoration and stewardship as envisioned by the USDOE involves technological development for dealing with hazardous wastes (USDOE, 1994a; 1999a, c), the additions we suggest do not involve large expenditures for new technologies, but rather a broadening of a stewardship mission to include NERPs and other buffer land. For the NERPs, and many of the other USDOE land, information is already available on the key ecosystems, target or endangered species and overall biodiversity. We suggest abandoning the default assumption that this land has low value (White & Rod, 1990) in favour of the assumption that all buffer land around USDOE industrial complexes is valuable and important to incorporate into a stewardship mission until proven otherwise.

We suggest that the USDOE should incorporate the buffer land around its hazardous waste sites and facilities into its stewardship mission, with the aim of preserving these intact, functioning ecosystems (see USDOE, 1994b, c; 1996b, c). As part of stewardship, the USDOE can define levels of access that depend

on uniqueness and diversity. This could be accomplished with the USDOE's existing mandate (order 430.1) (USDOE, 1994b), with internal regulations and procedures or with Congressional action. The Office of Environmental Restoration has developed detailed compliance and performance measures for the remediation and management of the risks from its hazardous wastes (USDOE 1994a; 1999a, c). Similar procedures and performance measures could be developed for the buffer land, including the NERPs. This could be accomplished by adding these responsibilities to the Office of Environmental Restoration, and developing performance measures for the stewardship of this land that are as rigorously pursued as the clean-up goals. These performance measures could include the maintenance of biodiversity or other indicators.

The stewardship goals as set forth by Oak Ridge Reservation (USDOE, 1998a) for dealing with radioactive and chemical wastes can be extended to include stewardship of the buffer ecosystems (Table 3). Long-term effectiveness involves redundant systems and controls, contingency plans, stable funding and a legal basis for long-term stewardship. The adaptation of these principles involves examining intact ecosystems on the buffer land in terms of long-term stewardship, and developing institutional and legal controls for the sustainability of these natural resources (Burger & Gochfeld, 1998). The seven elements Oak Ridge Reservation defined as essential to the stewardship of hazardous wastes (authority and funding, stewards, operations, physical controls, institutional controls, information systems and research) are equally important for stewardship of the NERPs and buffer land (USDOE, 1998a). We caution that wise stewardship of these lands requires the inclusion of all interested parties, such as Native Americans, who have social and cultural concerns about this land (Harris & Harper, 1998; Burger, 1999a), as well as recreationists (Burger, 1999c; Burger *et al.*, 1998, 2000).

The Office of Environmental Restoration has developed corporate performance measures, which do not include stewardship, but should. Instead, progress is measured as the number of release sites completed and the number of facilities decommissioned (USDOE, 1999c). Two phases are recognized within these: the completion of the assessment phase; and the completion of the release site or facility decommissioning. Both the assessment phase and the decommissioning could be aided by a wide variety of management tools, such as gap analysis (Prior-Magee *et al.*, 1998). Oddly, the Office of Environmental Restoration's glossary does not include stewardship, although it does define environmental restoration, legal authority for their remediation activities, stakeholder and several other remediation terms (USDOE, 1999c).

Conclusions

It is clearly important for the USDOE to take on a role of long-term stewardship of its hazardous waste sites that are too large or dangerous for remediation with today's technology. Herein we suggest that its stewardship mission should be enlarged to include the protection and wise use of the ecosystems that served as buffer zones around its hazardous sites. Some of these sites are uncontaminated, or only lightly contaminated, and have ecosystems that are critical to the surrounding regions. The legacy of the Cold War is the presence of defence facilities, military bases and other contaminated land used in a defence mission. Such facilities are present in many countries world-wide. These facilities, demil-

itarized zones and other protected military ecosystems have often had decades of limited human use, allowing functioning ecosystems to develop and flourish. While clean-up of these sites and restoration to appropriate land uses is laudable, we suggest that the relative importance of the buffer zones (in some cases designated as NERPs) to the local landscape should be examined, and that the USDOE should add the wise use and preservation of these ecosystems to its overall mission.

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