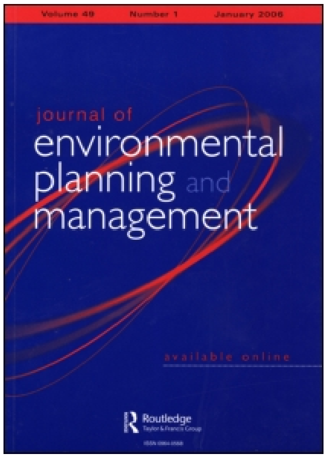

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POLICY AND PRACTICE

Defining an Ecological Baseline for Restoration and Natural Resource Damage Assessment of Contaminated Sites: The Case of the Department of Energy

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ABSTRACT *Retrospective ecological risk assessment, restoration, natural resource damage assessment (NRDA) and managing ecosystems all require having a baseline. This policy and practice paper explores the factors that influence baseline selection, and it is suggested that ecological resources would best be served by: (1) integrating NRDA considerations into both future land-use planning and remediation/restoration; (2) selecting a baseline for NRDA that approximates the land-use conditions at the time of occupation (or a preferred ecosystem); and (3) integrating both the positive and negative aspects of industrial occupation into restoration decisions, baseline selection and NRDA. Under the Comprehensive Environmental Response and Compensation and Liability Act (CERCLA), natural resource damages are assessed for injuries incurred since 1980 due to releases, but the release itself may have occurred before 1980. The paper uses the Department of Energy as a case study to examine NRDA and the management of ecosystems. Releases occurred at many DOE sites from the 1950s to the 1980s during nuclear bomb production. It is suggested that the DOE has been responsible not only for injuries to natural resources that occurred as a result of releases, but for significant ecosystem recovery since DOE occupation, because some lands were previously farmed or industrialized. Natural resource injuries due to releases occurred simultaneously with ecosystem recovery that resulted from DOE occupation. While the 1980 date is codified in CERCLA law as the time after which damages can be assessed, baseline can be defined as the conditions the natural resources would have been in today, but for the release of the hazardous substance. It is also suggested that NRDA*

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considerations should be incorporated into the remediation and restoration process at DOE sites, thereby negating the need for formal NRDA following restoration, and reducing the final NRDA costs.

Introduction

To accomplish remediation and restoration of contaminated lands, managers must have an ecosystem (or baseline) in mind. While numerous papers in the ecological literature have explored questions dealing with the selection of an appropriate ecosystem for restoration (Clewell & Rieger, 1997; Hobbs & Harris, 2001; Prach, 2004; Thom *et al.*, 2005; Baird, 2005), one major question facing managers is whether to mimic the ecosystem that was there at a previous time, or to create a different target ecosystem (White & Walker, 1997). This decision is fraught with ecological, economic, ethical, and aesthetic issues that are often difficult to resolve. However, practical issues clearly enter since there are limits to the kinds of ecosystems that can be restored on contaminated or degraded lands (Cairns, 1995; Ehrenfeld & Toth, 1997). While the ecological and economic issues often revolve around whether a given ecosystem can be restored on that site, and whether the resources required to do so are available, the ethical and aesthetic issues are more difficult to resolve (Egan & Howell, 2001). Should the habitat reflect an ideal ecosystem, a desired ecosystem or a previous ecosystem? Should the ecosystem be restored to the ecosystem that was on site 10 years ago, 100 years ago or 1000 years ago? Many lines of evidence can be used to select an ideal ecosystem, including historical, cultural and biological (Egan & Howell, 2001). Ultimately the decision of what ecosystem to restore lies with managers, public policy makers and the public itself.

For some sites, the decision about what ecosystem to restore may be constrained legally and by agreements among the regulators, natural resource trustees and parties responsible for the degradation. In the early 1980s the prevailing view was that contaminated sites should be cleaned up to residential standards to reduce risk, and returned to productive uses, very loosely defined. However, it has become increasingly clear that the cost of cleaning up sites to residential standards is prohibitive in terms of both costs and health risks (human and environmental).

This policy and practice paper examines the concept of a baseline for the purposes of both restoration of natural resources and Natural Resource Damage Assessment (NRDA), using DOE sites as a case study. These policy ideas and recommendations are based on 12 years of working on DOE sites by each author (e.g. Burger *et al.*, 1999, 2003, 2004, 2005, 2006; Snodgrass *et al.*, 2000; Solitare *et al.*, 2000; Salazar *et al.*, 2003; Greenberg *et al.*, 2003a, 2003b, 2005a, 2005b), on the work of others at DOE sites (e.g. Kunreuther *et al.*, 1990; Malone, 1990; Brown, 1998; Dale & Parr, 1998; Crowley & Ahearne, 2002; Whicker *et al.*, 2004; Macfarlane & Ewing, 2006), and on DOE documents (e.g. DOE, 1991, 1993a, 1993b, 1994a, 1994b, 1995, 2001). The paper explores the issue of what is a reasonable baseline for sites where chemical/radiological releases occurred over long periods, from multiple release sites, with multiple chemicals. It discusses background on NRDA and on the DOE, protecting natural resources on DOE sites, determining a baseline, policy implications for DOE, and policy and management implications more generally. Although the DOE is used as a case study, the issues are germane to many contaminated ecosystems.

Background on Natural Resource Damage Assessment (NRDA)

NRDA is the process whereby natural resource trustees assess damages for injuries to natural resources, recover costs of these damages and restore, replace or acquire the equivalent of the damaged resources and seek compensation for lost services (Helvey, 1991; Sheehy & Vik, 2003). Natural resource trustees are those entities that are legally responsible for protecting them, such as state and federal fish and wildlife agencies. NRDA must: (1) determine whether there have been injuries to natural resources caused by a chemical or radiological release; (2) calculate the costs necessary to restore (or replace) those resources; (3) calculate lost services or values; and (4) collect those monies or oversee natural resource restoration or replacement (DOE, 1993a, 1997). Natural resources under the Comprehensive Environmental Response and Compensation and Liability Act (CERCLA, section 101 [16]) are defined as "land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources", and they are evaluated by natural resource trustees. An injury to a natural resource is a measurable adverse change in the chemical or physical quality 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 (DOE, 1993b). Evaluation of such losses often involves ecological risk assessments (Bilyard *et al.*, 1993) and performance assessments of remediation and restoration (Malone, 1990).

Natural resource damages may be recovered by federal and state trustees, and by Tribal governments for injury to natural resources caused by releases after 1980 (Trimmier & Smith, 1995). Many NRDAs have also been conducted under the Oil Pollution Act (OPA) of 1990 (Austin, 1994; Burlington, 1999, 2002), and the Clean Water Act (Sheehy & Vik, 2003). The federal government has uniform rules and procedures for assessing economic losses and injuries developed by the US Department of the Interior (DOI) for CERCLA, and the US Department of Commerce for OPA (Deis & French, 1998; Ofiara, 2002). Several federal agencies have trustee responsibilities, including DOI and DOE.

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 (Grigalunas *et al.*, 1988; Higley *et al.*, 2003a, 2003b). Biological assessment is difficult because of response time variations among species and ecosystems (Barnthouse & Stahl, 2002). 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 release. The long response times also means that ecosystem recovery can take years or decades, which must be accounted for in NRDA.

Background on the DOE

During and after the Second World War, the predecessors of DOE obtained many tracts of land for developing, producing and testing nuclear weapons. Many sites were rural, and ranged from relatively undisturbed forests and shrublands to those extensively farmed and grazed. In some places, such as the Savannah River Site (SRS) in South Carolina, small towns were moved or displaced. Secrecy shrouded the establishment of the DOE complex, and the public and regulators did not attend to degradation and environmental pollution. The Cold War and nuclear weapons production ended abruptly in 1989, and the DOE established an Office of Environmental Management (EM) to deal with remediation (Sink & Frank, 1996; Daisey, 1998). The DOE is responsible for over 100 sites in 34 states, ranging in size from less than a city block to areas exceeding 1000 square miles (2560 km^2) (Crowley & Ahearne, 2002).

In the early 1980s, environmental concerns led the DOE to enter into a series of compliance agreements with the US Environmental Protection Agency (EPA) and state agencies to clean-up contamination (called Tri-party agreements), largely in the absence of adequate data on the magnitude of contamination or the costs of clean-up. The DOE's remediation was largely driven by compliance with CERCLA, the Resource Conservation and Recovery Act (RCRA), and these tri-party compliance agreements. Depending upon the site, DOE sites are subject to regulations of the EPA, NRC and appropriate state agencies and Tribal Nations (Bascietto *et al.*, 1990). DOE sites have highly toxic and long-lived radiological wastes, both in storage facilities and as surface and groundwater contamination (Crowley & Ahearne, 2002). Although there are limitations on the types of remediation that are possible given high remediation costs, transportation difficulties and technology constraints, significant public discourse should include the ecological, political and societal issues concerning remediation, restoration and NRDA.

While trusteeship of natural resources has fallen largely to the DOI, which is trustee for resources on 450 million acres (20% of the United States, Executive Order 12580; Deason & Taylor, 1998), the DOE also has resource trustee responsibility on its sites. To some extent the DOE has a conflict of interest since any ecological data acquired by the DOE as a result of its trusteeship responsibilities are discoverable by the other trustees. The DOE began to consider screening of natural resources on their lands (DOE, 1991, 1993a, 1993b), but these require commitment complex-wide. For example, SRS developed a NRDA implementation project in 1995 (DOE, 1995), but such plans did not move in step with remediation goals.

Protecting Natural Resources on DOE Sites

Even though DOE lands were extensive and ecologically valuable (Dale & Parr, 1998; Burger *et al.*, 2003), protecting ecological resources was not initially part of the DOE's mission. However, the ecological importance of seven of the largest DOE sites was recognized as early as the 1970s through their designation as National Environmental Research Parks (NERPs) (DOE, 1994a, 1994b). The DOE's stewardship program (DOE Order 430.1) has the goal of achieving sustainable development through ecosystem management of its lands as valuable national resources (Malone, 1998). The DOE order included integrating economic, ecological, social and cultural factors into land-use decisions. Many of the most contaminated sites are already sustaining both DOE missions and natural resource protection through comprehensive resource management and remediation (Malone, 1998).

Nelson (2001) and Burger *et al.* (2003) suggested that assuring long-term protection of human health, cultural values and high levels of biodiversity and ecological integrity may lead to the protection of some DOE sites as ecological preserves.

While DOE lands have experienced a range of stresses over the last half-century (physical disruption, human disturbance, chemical/radiological exposure), many of their buffer lands were protected from any direct exposure to people. Even though some are contaminated, the 2.54 million acres of DOE land comprise a reservoir of considerable ecological value (Brown, 1998). Approximately 79% of this land has been undisturbed for over 50 years because it served to buffer the nuclear production facilities (DOE, 2001), which now offer some of the finest and least disturbed plant and animal habitats in the US (Brown, 1998; Dale & Parr, 1998; Burger *et al.*, 2003). This is undoubtedly a large net increase because some of the larger DOE sites were largely farmland prior to DOE occupation (DOE, 1994a, 1996a).

There are many different ways to measure the ecological value of DOE sites, including numbers of endangered and threatened species, unique species assemblages, and unique habitats. Of the 25 DOE sites slated for remediation and restoration (out of over 100 sites), the study found that 56% had federal endangered or threatened species, and 76% had state endangered or threatened species (Burger *et al.*, 2007a). Species richness of birds, mammals and reptiles (but not amphibians), and the number of available habitats, were directly related to both total acres and total non-industrial acres of sites (Correlation coefficients of over 0.41, $p < 0.01$).

Some DOE sites have truly unique habitats, often some of the only remaining habitat type in the region (DOE, 1996a). The SRS has most of the remaining Carolina Bays, and the Idaho National Engineering and Environmental Laboratory has some of the only pristine shrub-steppe habitat in the region (DOE, 1996b). The Hanford Site has the only free-flowing stretch of the Columbia River, an important spawning region for Chinook salmon, and its Arid Lands Ecology Reserve encompasses most of the remaining natural desert steppe habitat in Washington (Geist, 1995; DOE, 1996c). The Los Alamos National Laboratory is adjacent to large tracts of federal lands (Bandolier National Monument) that would benefit from additional lands (LANL, 1998). Other DOE sites also have valuable resources: Brookhaven National Laboratory has some of the only undisturbed Pine Barrens habitat left in New York State (DOE, 2002).

Three aspects of remediation of DOE lands should be mentioned: (1) most of the land, especially on large sites, is uncontaminated, and remediation on the contaminated lands may disrupt ecosystems on uncontaminated parts (Dale & Parr, 1998; Burger *et al.*, 2003, 2007a); (2) while remediation has been determined by agreements between the EPA, state regulators, and the DOE (DOE, 2003; Geiser, 2003), the degree of remediation, and its relationship to restoration of natural resources, is unclear; and (3) the ecosystem recovery on some DOE lands resulted in intact ecosystems, with appropriate structure and function. Planting a few trees on waste landfills or grasses on the edge of toxic waste ponds does not constitute ecosystem recovery. Finally, there is congruence between the optimal path to integrated ecosystem recovery for both the DOE, natural resource trustees and the US Justice Department. The DOE has a stake in integrating natural resource claims at the time of remediation and restoration because both time and money can often be saved. If there are NRDA claims, it is the Justice Department that makes the actual payment. Thus, all parties have a stake in addressing the NRDA issues earlier and more efficiently.

Determining a Baseline for DOE Sites

Defining a baseline is a key issue for restoration and NRDA on contaminated sites. Under CERCLA, only damages that occurred after 1980 are recoverable by trustees, a point that is often misunderstood. However, the damages also encompass the condition the natural resources would have been in today except for the release (which could have occurred in 1960, 1950 or any other year). The 1980 date is relevant for setting the cut-off date for compensable monetary damages only (Burger *et al.*, 2007b). Some managers misunderstand the nature of the 1980 cut-off date, and assume that it is the baseline. Two major issues surround the 1980 date: (1) injuries may have occurred on an ecological palette of already injured resources, populations may have declined seriously or been extirpated by previous releases, making it difficult to determine the injuries that would have occurred on resources since 1980 (had they not already been injured); and (2) the injuries that occurred since 1980 may have taken place on resources that were already largely restored from pre-DOE degradation. Each of these will be discussed below.

First, for some contaminated sites, the injuries that occurred from 1980 to the present took place on ecosystems that were already impacted; degradation due to releases is a combination of all the injuries since DOE occupation (Figure 1). For some sites, such as the SRS, the major degradation occurred from 1950 until 1960, and recovery followed (DOE, 1995; Whicker *et al.*, 2004). Even though damages are

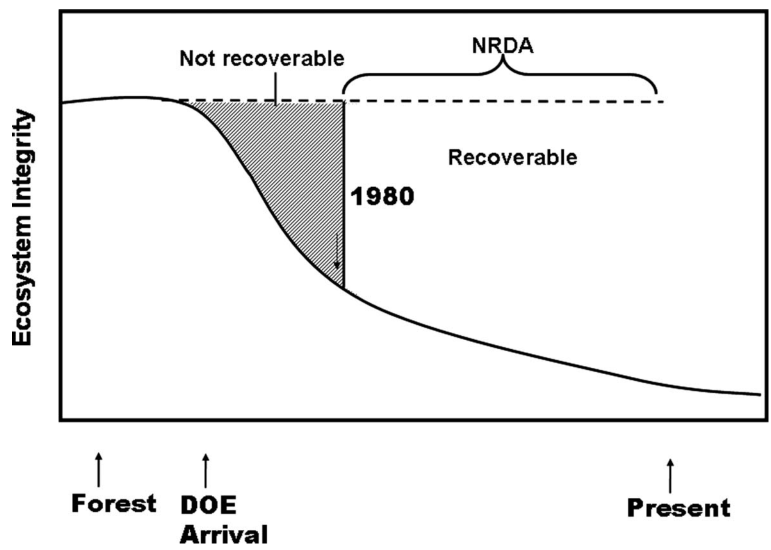

Figure 1. Example of potential degradation caused by DOE occupation of a pristine site and the relative degradation before and after the CERCLA 1980 cut-off for Natural Resource Damages that can be claimed as a result of releases (date of releases can be pre-1980).

not recoverable for the injuries before 1980, the baseline is still the state of the resources prior to 1980 (see Figure 1). It may not be possible to determine the extent of damages to populations that should be there (and were prior to the DOE arrival), but have already been extirpated.

Second, the injuries that have taken place since 1980 may have occurred on an ecosystem that has undergone recovery from a pre-DOE degraded land use. That is, if the DOE site had been extensively farmed, grazed or used for industrial/residential purposes, then occupation by the DOE might have resulted in ecosystem recovery. While such recovery was not the result of restoration (with associated costs), recovery did, in fact, occur. For example (Figure 2, top), if the land the DOE purchased was previously used for farming, the land would have been exposed to physical disruption (removal of trees, shrubs and grasses), human disturbance on the site and agricultural chemicals. All of these might have led to massive degradation. The DOE often built industrial facilities on only a small portion of a site, and the rest was left alone as a buffer to prevent risk to humans and for security. For DOE buffer lands, physical disruption and human disturbances ceased abruptly, and agricultural chemical effects slowly declined. In contrast, the industrial areas of DOE sites were exposed to physical disruptions due to building facilities, and to radiation/chemical releases (Figure 2, bottom). When buffer lands were left alone, natural succession replaced farmland with forests or grasslands. It is argued that the injuries since 1980

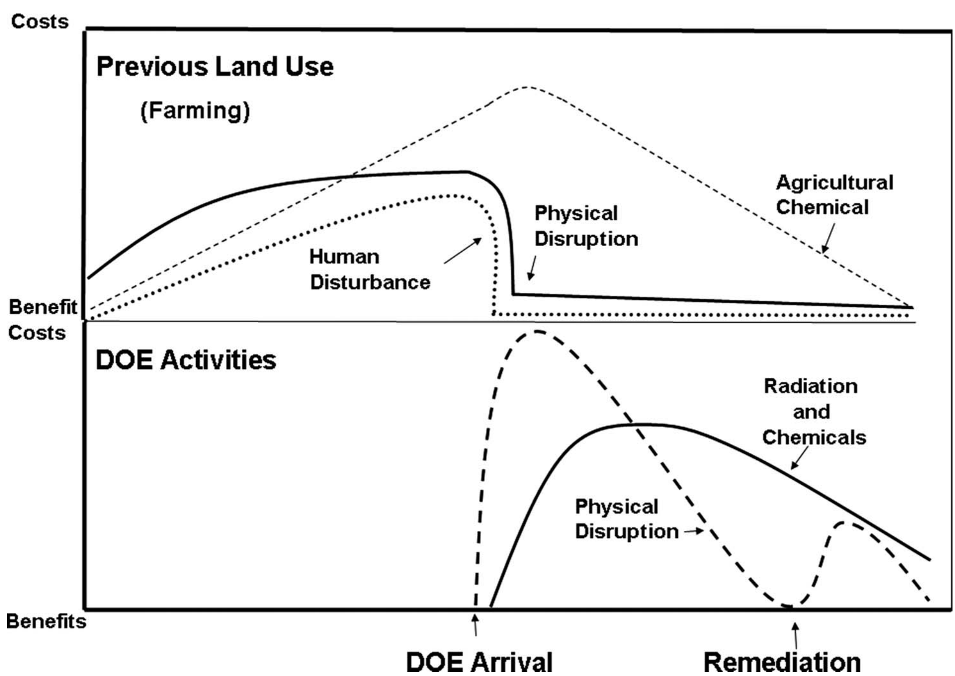

Figure 2. Effects of previous land use (i.e. farming) on ecosystem health and subsequent recovery when DOE arrived (top panel), and costs and risks from DOE activities themselves (bottom panel).

that occurred due to releases were on top of a much larger component of ecosystem recovery that resulted from DOE activities.

There are many possibilities for the effect of the DOE on natural resources. If there was a natural ecosystem, such as a forest or grassland, then the arrival of the DOE may have at best had no effect, and at worst, had a negative effect (Figure 3). However, if the previous use was farmland or residential, then the activities of the DOE might have had quite positive effects, the degree of positiveness depending upon how much of the land was allowed to revert to a natural ecosystem (Figure 3).

The above considerations suggest that the designation of 1980 as the baseline without reference to previous conditions (both recovery and degradation) caused by the DOE does not serve the ecosystem well. If the point of NRDA is to restore injured resources caused by releases, then it is suggested that the resources at risk from DOE occupation should include considerations of those at the time of DOE occupation, in 1980 and at present. If there has been significant ecosystem recovery, modified only by a decrement caused by exposure to chemicals and radionuclides, then recovery of natural resources might best be served by acknowledging the positive ecosystem recovery that has occurred. Under such circumstances, the successional recovery that has occurred should not be obliterated by massive remediation to remove minor contamination (Dale & Parr, 1998; Burger *et al.*, 2003). For example, massive removal of contaminated soil destroys ecosystems, and the building of roads through intact ecosystems can bring in invasive species, isolate populations and cause human disturbance to breeding populations. While ecosystems might benefit from minor physical remediation to remove contamination,

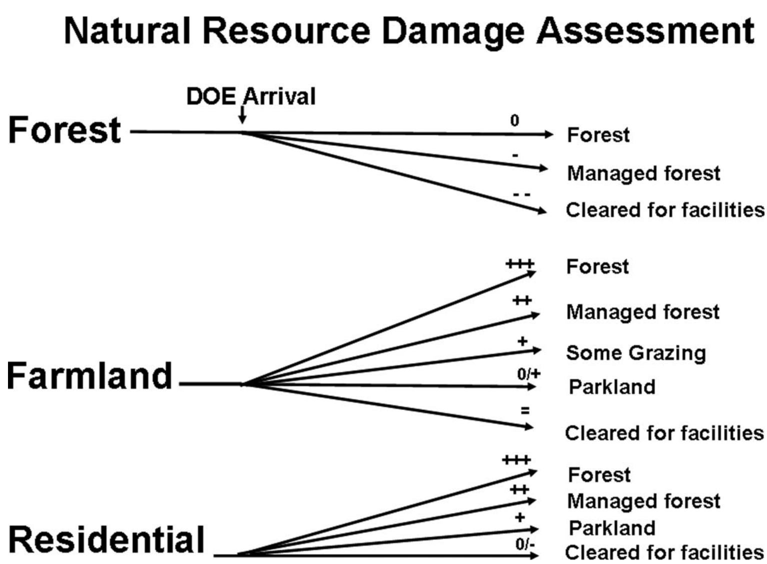

Figure 3. The range of possible ecosystem benefits and costs from DOE management on different types of ecosystems. Forest represents natural functioning ecosystems and could represent other ecosystems, such as grasslands and shrub-steppe. + equals a positive benefit, 0 = no cost or benefit, and - = costs.

massive physical disruption of soil and plant communities would surely be injurious to the natural resources (Whicker *et al.*, 2004).

From the discussion above, it follows that there are two baselines that are often confused in NRDA discussions: the baseline for the purpose of natural resource assessments and the baseline for injuries that are recoverable. The baseline for damage recovery for injuries is 1980, but the baseline for determining injuries is the state of natural resources before the release(s) occurred, whenever it was.

Policy Implications for the DOE

The DOE is faced with massive clean-up, as well as NRDA for its contaminated sites. While NRDA often occurs following the completion of the remediation/restoration process, it is suggested that it makes more sense to integrate NRDA considerations during the determination of future land use and the remediation/restoration phase. This has the advantage of restoring natural resources earlier, reducing injuries during the remediation phase, integrating natural resource trustees during the whole process, reducing the remediation/restoration costs overall because there will be some cost savings due to simultaneous physical remediation and reducing the costs of assessment of the damages to natural resources. A whole range of other stakeholders (government officials, NGOs and the public) should also be involved in the NRDA decisions, together with natural resource trustees (Burger *et al.*, in press).

One key aspect of NRDA is the determination of the injuries for the purposes of NRDA, and this entails demonstrating injuries to natural resources. Damages do not occur until someone incurs an expense or suffers a loss of use or enjoyment as a result of the releases. One advantage of integrating NRDA into remediation and restoration is that it might inform the determination of future land use, and eliminate the cost of assessing resource damages by both the natural resource trustees and the responsible party. Further, natural resource trustees may prefer that DOE lands be restored to some functioning ecosystem (e.g. forest, grassland, shrub-steppe) rather than its pre-DOE conditions (e.g. farmland, grazing lands). Restoration to a functioning ecosystem may be less costly in time and money than remediation to farming or residential standards because the soil would not have to be restored completely (often involving removal of contaminated soil and replacement with topsoil). For example, at Fernald, the integration of NRDA into the remediation/restoration process by the DOE resulted in restoration to parklands and natural ecosystems, rather than the complete removal of all contaminated soil and restoration to farming standards (the pre-DOE condition).

The integration of the positive as well as the negative impacts of DOE occupation into natural resource injury assessment by natural resource trustees would provide a more complete examination of the future land use options and of the total resource injury. That is, if the DOE started with already degraded land (which had been converted to farmland, industrial purposes or residential), and allowed succession to occur to functioning ecosystems, then these positive benefits would be considered together with the injuries from chemical/radiological releases. This would have the benefit for the DOE of reducing possible NRDA costs, reducing the total time and cost devoted to remediation/restoration, and lead to more timely closure of sites. If at the time of remediation/restoration, the degraded land had reverted to functioning ecosystems (such as forest, grasslands, Carolina bays or shrub-steppe), then DOE and natural resource trustees should be allowed to select these habitats as the preferred ecosystem.

Management and Policy Implications

Recognition that there are two baselines (1) the use of 1980 for damage assessment, as stipulated in CERCLA or other comparable laws, and (2) the state of natural resources before the releases, could lead to more timely completion of the remediation/restoration process, including restoration, replacement, or preservation of natural resources. Enhancing and creating natural ecosystems could occur at the time of remediation. Soil removal from pits or trenches could lead to the creation of lakes and ponds with appropriate infalls and outfalls. Low-level contaminated soils removed from sensitive areas could be used to create hills and berms for lakes and topographical relief. Land left barren by removal of contaminated buildings could be allowed to revert to natural ecosystems, aided by seedings and plantings, leading to the creation of grasslands and early successional stages, habitats that are often in jeopardy. Both biological and physical aspects of restoration are key to recovery.

Consideration given to the responsible parties for positive aspects of their occupation could offset punitive damages and aid in good relationships between the responsible parties and natural resource trustees because negotiations will not be as adversarial. That is, the DOE can lay claim to positive, as well as negative effects. Further, early consideration of NRDA might lead to the option of preserving the natural ecosystems currently on contaminated land (Burger *et al.*, 2003). The DOE is not the only agency that would profit from re-naturalizing rural or low-value contaminated land, the private sector would as well. Finally, the condition in 1980 (for US CERCLA sites) may not be the one that either the natural resource trustees prefer, or the DOE can easily remediate to achieve. It may also not be the one that local and regional public officials and stakeholders want (Greenberg *et al.*, 2001).

This paper has suggested that managers and natural resource trustees should consider: (1) selecting a baseline for NRDA that approximates the land-use conditions at the time of DOE occupation or selecting a more desired state for that site; and (2) integrating both the positive and negative aspects of DOE occupation into restoration decisions, baseline selection and NRDA. These require a modification of the way NRDA is implemented by agencies and natural resource trustees. Although NRDA damages may be recovered by natural resource trustees for injury to natural resources caused by releases after 1980, the baseline for the state of natural resources is not 1980, but pre-release conditions. Since NRDA requires an assessment of those damages and demonstration of injury, these costs could be reduced by going directly to improving and restoring the resources while conducting remediation and restoration. If communication is open between the entities during decision making about remediation, then the parties can discuss what damages might have occurred (without necessarily enumerating or documenting the injuries) within a context of moving forward to an agreed-upon condition for the natural resources.

In some cases, or for some parts of contaminated sites, restoration of natural resources may not be possible or desirable. A heavily industrial site may remain an industrial park, but adjoining parts of the site may be restored to functioning ecosystems. Such discussions might involve trade-offs to restore the resources to the maximum possible within the constraints of the releases or the contamination present and incorporating considerations of resource injuries and resource restoration within the context of remediation.

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