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Measuring the Social Benefits of EPA Land Cleanup and Reuse Programs

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Abstract

The EPA has a cornucopia of cleanup and reuse programs ranging from the Superfund Program which addresses sites posing imminent danger and many of the most hazardous sites nationwide, to the Brownfields Program which addresses lower risk sites. These programs provide a common set of primary benefits: reductions in health risks and ecosystem damages, and improvements in amenity values. Indirect benefits include changes in factor, especially land, productivity. A different indirect benefit stems from better information in land markets compared to when land is contaminated, a situation that seems marked by asymmetric information and that might depress the frequency of land transactions. Both indirect benefit categories are a result of the primary benefits and would not be added to them. Cleaning up and reusing urban contaminated sites might generate two additional types of benefits: preservation of green space, and agglomeration benefits. Limited empirical work has addressed each of these benefit categories.

Taken as a whole, the literature providing information on the social benefits of cleanup and reuse is spotty and incomplete and perhaps raises more questions than it answers. Would a comprehensive study of the benefits of all cleanup programs, or even of all aspects of one program, do better to focus on primary effects or property value changes? What is the appropriate baseline for hedonic studies? Under what conditions does reusing contaminated land deter greenfield development on the urban periphery?

Keywords: hazardous waste sites, land revitalization, brownfields
Subject Areas: Hazardous Waste, Valuation Methods, Benefit-Cost Analysis

Introduction

Increasingly, the public, Congress, and policy makers seek benefits information as policies, budgets, and legislation are developed. For example, the EPA and other regulatory agencies are required to report estimates of the social benefits and costs of major rules to the Office of Management and Budget (OMB). Each year, OMB reports to Congress an estimate of the cumulative benefits and costs of federal regulation. Within the EPA, program-specific benefits information would be useful to developing EPA's strategic plan and to implementing the Government Performance Results Act. In response to this need, over the past couple of decades, methods have been developed to assess the social benefits and costs of most of EPA's major programs, with an important exception. Programs targeting land cleanup and reuse are still in need of accessible methodologies to assess their welfare effects.

The EPA administers a cornucopia of cleanup and reuse programs. They range from the Superfund Program which addresses sites posing imminent danger and many of the most hazardous sites nationwide, to the Brownfields Program which addresses lower risk sites. There is agreement that these programs provide a common set of primary social benefits: reductions in health risks and ecosystem damages, and improvements in amenity values. While EPA has some understanding of the social costs of these programs, information about the magnitude of benefits is sparse. There is also a general lack of clarity about the categories of indirect benefits associated with these programs.

This need for benefits information regarding land cleanup and reuse programs persists despite efforts on the part of EPA analysts and the wider academic research community to develop reasonable benefit measures. In 2002, a Science Advisory Board

(SAB) Panel reviewed an EPA proposal to assess the benefits and costs of two cleanup programs, UST Cleanup and RCRA Subtitle C. In early 2006, a different SAB Panel reviewed a proposal to assess the benefits of Superfund. Both panels encouraged the EPA to focus attention on a long term strategy for developing appropriate frameworks, methods and data to enable benefits estimation.

The first step to measuring the benefits of land cleanup and reuse is to clearly describe benefit categories or, stated differently, the routes through which contaminated land affects social welfare.[1] Contaminated land can be a source of tainted soil, polluted water, airborne toxins, or unsightly vistas. This paper identifies five different, though sometimes overlapping, categories of welfare changes due to these conditions. The first three categories apply to contaminated land generally: primary effects on utility including health, ecosystem and amenity effects, indirect effects on productivity, and depressed property transactions. Two additional categories apply primarily to contaminated land in urban settings: potential greenfield-saving effects of redevelopment, and agglomeration effects. Empirical research exploring these welfare changes is sparse for all categories except for the indirect effects on land productivity.

The remainder of this paper is organized as follows. Section II describes EPA cleanup and reuse programs, including brief descriptions of state programs. Section III explains the five benefit categories and summarizes the empirical work relevant to each. A large portion of this section is devoted to a graphical analysis of the effect of

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[1] We use the term "welfare" in the traditional sense used by economists to refer to a social welfare function wherein individual consumers' utilities are represented. We do not mean to interpret the term as it appears in CERCLA where the EPA is directed to take action at contaminated sites that pose "a substantial endangerment to public health or welfare or the environment." Furthermore, to the extent that the discussion of benefits in this paper suggests an eventual comparison with costs, such a comparison might be inappropriate when considering specific contaminated sites. For example, CERCLA does not allow such comparisons.

contamination on land markets and to the numerous hedonic analyses of these markets. Finally, we conclude with a discussion of the many questions that remain with regard to the social benefits of land cleanup and reuse.

II. Evolution of EPA Cleanup and Reuse Programs

EPA cleanup and reuse programs each have their own unique history and set of policy objectives. The outcome is a set of regulations and policies that addresses different severities and sources of contamination and different categories of parties that are responsible for cleanup (including site owners and operators, generators, and transporters). Aside from the Superfund and Federal Facilities Programs, most EPA regulation targeting cleanup and reuse is set up for states or local governments to be the implementing agencies. In general these policies have met their primary objective of improving human health and the environment by both preventing large new sources of land contamination and cleaning up already contaminated sites. The number and variety of programs has resulted in a complicated web of sometimes overlapping policy. In the following paragraphs, we briefly describe the authorizing legislation and primary objectives of each program, provide descriptive statistics when possible, discuss the role of state governments, and identify policies or special programs regarding reuse. We close with a description of two recent initiatives that emphasize the importance of consistency and reuse across cleanup programs.

Superfund

To address abandoned waste sites, in 1980, Congress passed the Superfund Act, formally the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Superfund law as originally passed allows EPA to take action at contaminated sites that pose "a substantial endangerment to public health or welfare or the environment" (Walker, Sadowitz, and Graham, 1995, p26).[2] The law includes a liability provision that assigns financial responsibility for cleanup to the parties responsible for contamination. Courts have interpreted CERCLA to impose joint and several liability on potentially responsible parties for any indivisible harm caused by the contamination. Indirectly, the liability provisions can also serve as a deterrent to potential future contaminators.

There are two major categories of cleanup activities within the Superfund program. The first is known as the removal program which generally is tasked with quickly cleaning up sites posing or with the potential to pose imminent health risk. Because of their speedy nature, removals are generally conducted following only a preliminary assessment to determine whether the site poses potential risk to public health. In general, removal actions significantly reduce immediate risks. EPA has completed approximately 7,900 removal actions since the inception of the program, averaging about 325 annually during the 1990s (Probst and Konisky 2001). The majority of these removals have been conducted at sites that are ***not*** listed on the well known National Priorities List (NPL). The removal program accounted for approximately 20% of total Superfund expenditures in 1999 (Probst and Konisky 2001).

[2] CERCLA was amended in 1986 with the Superfund Amendments and Reauthorization Act (SARA). See http://www.epa.gov/superfund/action/law/sara.htm for an overview of changes and additions to the program made by SARA:

The second part of Superfund, known as the remedial program, is responsible for long term cleanups of sites listed on the NPL. The remedial program generally undertakes more extensive risk assessment than the removal program. In order to be placed on the NPL, a site is screened through the "Hazard Ranking System," which considers contaminants and human exposure routes. An analysis of risk information contained in 1991 Records of Decision (RODs) for NPL sites suggests that both noncancer and cancer risks are usually present. While most Superfund site risk assessments evaluate a range of exposure pathways, the maximum risks are most often posed by exposure to groundwater contamination (Walker, Sadowitz, and Graham 1995). The remedial program spent approximately 40% of total Superfund expenditures in 1999 (Probst and Konisky 2001).[3] Over 1500 sites have been placed on the NPL to date, with over 60 % currently in the final "construction complete" stage (US EPA 2005a). In practice, these sites have both removal as well as remedial actions.

While states and communities are involved in remedial actions at federal NPL sites, many states have also developed their own "superfund" programs with associated state "superfunds."[4] These programs often handle sites that receive lower HRS scores than would be eligible for the federal NPL but they may also manage sites that are eligible for the federal program. An outcome of the proliferation of state programs is that NPL sites are more accurately characterized as in need of federal funding and oversight than as posing the greatest risk (Probst and Konisky 2001).

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[3] The remaining 40% of the Superfund Program's expenditures in 1999 were on program management and administration, site assessments, and other miscellaneous categories. For details, see Figure 1-2 in Probst and Konisky (2001).

[4] For descriptions of the New York and Texas Superfund Programs, see http://www.dec.state.ny.us/website/der/ihws/ and http://www.tceq.state.tx.us/remediation/superfund/assessment/index.html.

RCRA Corrective Action

As the Superfund program was carrying out removal and remedial actions at high risk sites contaminated by prior actions, a separate program authorized by Subtitle C of the Resource Conservation and Recovery Act (RCRA) was also evolving. RCRA Subtitle C imposed cradle-to-grave standards for managing hazardous wastes. In 1984, based on the corrective action provisions in the Hazardous and Solid Waste Amendments to RCRA, the Corrective Action Hazardous Waste Cleanup Program was initiated to handle accidents and other hazardous releases by RCRA facilities that have (or have sought) permits as hazardous waste treatment, storage, and disposal facilities. Gradually, the program was expanded to include other RCRA facilities at which significant releases have occurred. The Corrective Action Program compels responsible parties to investigate and clean up their own hazardous releases. Unlike Superfund sites, RCRA Corrective Action sites generally have ongoing operations and readily identifiable operators.

Cleanup operations at Corrective Action sites are not separated into removals and remediation as under Superfund.[5] RCRA corrective action sites are separated into three categories according to severity of risk. This ranking is based on the National Corrective Action Prioritization System (NCAPS) which takes into account factors including contamination and potential exposures. Over 5,000 facilities have been identified as subject to RCRA Corrective Action; of these, almost 2,000 have been identified as "high priority" and as such are first in line to be remediated. By 2005, "unacceptable human exposures" had been eliminated at over 95 % of the high priority sites. At approximately

[5] In fact releases on RCRA sites that are in need of emergency response are typically handled by the Superfund removal program.

70% of these sites there was evidence that groundwater contamination was no longer spreading.[6]

The primary responsibility for implementing RCRA is delegated to individual authorized states. EPA regulations set minimum standards but states have the option of establishing their own higher standards. Forty one states are authorized to implement the Corrective Action program. In practice, state officials are the primary decision-makers regarding RCRA Corrective Action sites.

Underground Storage Tank Program

In 1984, to address the growing problem of petroleum[7] and other hazardous substances leaking from underground storage tanks (USTs), Congress added Subtitle I to RCRA. In response, in 1988 EPA established a regulatory program that specifies technical requirements to prevent, detect, and cleanup UST releases and that establishes financial responsibility requirements for UST owners and operators. The UST Program also administers the Leaking Underground Storage Tank (LUST) Trust Fund to pay for cleanups at sites where the owner or operator is unknown or unwilling or financially unable to take responsibility for the cleanup. As of 2005, out of 450,000 confirmed releases from tanks, almost 350,000 cleanups had been completed.[8]

As with most other federal programs under RCRA authority, states are the implementing agencies of UST regulations. In the late 1990s, the federal program encouraged states to adopt a risk-based approach to their corrective action programs to improve consistency across states in cleanup prioritization and efficiency at LUST sites.

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[6] See http://www.epa.gov/correctiveaction/.
[7] CERCLA specifically excludes sites contaminated by petroleum.
[8] See http://www.epa.gov/OUST/pubs/ustfacts.htm for more on UST program facts.

Many states followed a model, 3-tiered-approach, consistent with EPA risk assessment guidelines and procedures called Risk-Based Correction Action (RBCA) that was developed by the American Society for Testing and Materials as an environmental cleanup standard. Some states have more stringent rules than required by the federal program.

Federal Facilities

More than 57,000 federal sites are potentially contaminated; from nuclear weapons plants and military bases to landfills and fuel distribution stations. For a subset of these sites, EPA's Federal Facilities Restoration and Reuse Office (FFRRO) works with its ten regional programs, and with the U.S. Department of Defense (DoD), Department of Energy (DoE), and other federal entities to facilitate faster, more effective and less costly cleanup and reuse.

EPA's Superfund Federal Facilities Response Program (SFFRP) provides technical and regulatory oversight at the 172 federal facilities that have been listed on the NPL. As of 2005, approximately 50 of these are in the "construction complete" phase of cleanup. At NPL facilities, the program negotiates cleanup agreements with other federal agencies, approves other agencies' cleanup remedies, and provides technical assistance throughout the cleanup process. Approximately 80 percent of NPL federal facilities are DoD sites, 12 percent are DoE's, and the rest are split among other federal agencies.

EPA is also actively involved in the DoD Base Realignment and Closure (BRAC) Program. Under the Clinton Administration, the Fast-Track Cleanup Program was initiated to accelerate cleanups and economic recovery of communities affected by four initial rounds of BRAC. Since 1993, EPA's BRAC program has worked with DoD, state environmental programs, local governments, and communities to make property suitable for transfer, while ensuring protection of human health and the environment.[9]

Brownfields Program

By the 1990s, sites contaminated by prior use, hazardous releases at TSDs or other RCRA facilities, and leaking underground storage tanks had all been the target of environmental policy at the federal and state levels. As these pressing problems were addressed, attention turned to a more subtle but growing issue: sites that were not contaminated enough to fall under existing programs and yet the environmental concerns were a barrier to reuse. In addition to posing possible health risks, these un-used sites were often unsightly and occupied land that had potential to invigorate surrounding communities. GAO estimates there are about 450,000 such "brownfield" sites in the U.S.

In 1995, EPA launched its Brownfields Initiative to facilitate cooperation among states, communities, land owners and other stake holders to assess, cleanup and reuse brownfields. During the program's initial years, EPA provided seed money to local governments to help fund brownfield pilot projects. In 2002, Congress passed the Small Business Liability Relief and Brownfields Revitalization Act (Brownfields Law) which codified and expanded EPA's existing Brownfields Initiative. The Brownfields Law defines a brownfield as "a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant."

[9] See http://www.epa.gov/swerffrr/about_ffrro.htm for more information about FFRRO activities.

The Law also clarified Superfund liability protections for certain parties including bona fide prospective purchasers, innocent landowners, contiguous property owners, and others. The effect was to make it easier for brownfields to pass into productive uses.[10]

The Brownfields Program provides competitive grants to help communities assess and cleanup brownfields. It has separate competitions for numerous categories of grants: site assessment; revolving loan funds to capitalize loans used to do cleanups; site cleanup; and others. The applications are evaluated according to criteria specified in the annual competition guidelines (U.S. EPA 2005b). Since the Brownfields Law was passed, EPA has provided almost 900 assessment grants for more than $200 million. Approximately 30 percent of brownfields sites have been found to have contamination lower than would be of regulatory concern. The Program also provides funds to establish and enhance state and tribal "response programs." These programs vary by state but include both regulatory and incentive-based programs. Many of the state programs have cleanup standards that acknowledge the end use of the property, such as residential, commercial, or industrial; others to use limits or restrictions on use (US EPA 2005c).

One Cleanup Program and The Land Revitalization Initiative

In April 2003 EPA announced its One Cleanup Program in an effort to give communities a simple straightforward approach for cleaning up and reusing any and all contaminated sites within their boundaries. The One Cleanup Program seeks to encourage better teamwork among EPA's cleanup programs to improve the coordination, speed, and effectiveness of cleanups at the nation's contaminated sites. Hopefully, this will also generate clearer and more useful information for communities. Finally, the

[10] See http://www.epa.gov/swerosps/bf/html-doc/2869sum.htm.

Program aims for better measurement of cleanup performance results. (US EPA 2003a, 2003b) The initiative clearly signaled a shift within EPA towards a focus on improving consistency across cleanup programs.

In order to assign permanence to the One Program idea and extend concern to reuse of remediated sites, EPA established The Land Revitalization Office (LRO) in September 2004. The Land Revitalization Initiative is a cross-program effort to emphasize that cleanup and reuse are mutually supportive goals and that consideration of anticipated property reuse should be an integral part of EPA's cleanup decisions. According to the LRO website, "Whether a property is a Superfund site, an operating waste disposal site, a petroleum facility, a former gas station, or an abandoned industrial facility, EPA believes that environmental cleanup and land restoration across all EPA programs must be achieved." Practical LRO activities include development of cross-program measures of land reuse outcomes, public outreach, and promotion of tools that address barriers to land revitalization.[11] The current document is an effort funded in part by the LRO.

III. Social Benefits of Cleanup and Reuse

The social benefits associated with EPA's different cleanup and reuse programs have proven elusive to conceptualize and measure. To date, there has been no systematic accounting of the social benefits of any EPA clean up program although, as mentioned above, two efforts have been made within the Agency to propose how such an analysis could be conducted. In this section we will describe the benefits that we suspect result

[11] http://www.epa.gov/swerrims/landrevitalization/lrso.htm.

from cleanup and reuse and summarize the empirical literature relevant to each category of benefits.

Five Benefit Categories

Contaminated land can be a source of tainted soil, polluted water, airborne toxins, or unsightly vistas. First and fundamentally, these conditions can affect utility directly by affecting health, ecosystem services, and amenities. Perhaps less obvious, the conditions associated with contaminated land can also affect utility indirectly through changes in factor productivity. It may be more expensive to produce goods or services on contaminated land: doing so could require more expenditure on keeping equipment clean, securing products from contamination, or protecting workers from health risks. Contaminated land may oblige households to spend more of their time and money to prevent negative effects on health, ecosystem services, and amenities. This leaves them with less time and money to spend on the other things they enjoy. Welfare changes due to changes in land productivity are not exclusive from those associated with direct changes in health risks, ecosystem services, and amenity values.

Another indirect effect of contaminated land on welfare is due to problems associated with asymmetric information. Asymmetric information regarding the extent of contamination may prevent land-market transactions. This, in turn, means that land will not necessarily be used by the most productive owner or devoted to its "highest and best use". Ultimately, this means that society will be afforded fewer of the goods and services that provide its members with utility than it would if information about land conditions were better.

Finally, two additional potential effects on social welfare are caused by the failure to reclaim and reuse contaminated land in urban settings. Contamination, or even suspected contamination, of "brownfields" can accelerate new construction and development of "greenfield" areas. This may, in turn, impose externalities if lands at the urban fringe shelter biodiversity or provide other public goods (such as ecosystems services; see, e.g., Daily 1997). A second way in which the reuse of urban "brownfield" sites may contribute to welfare is through economies of agglomeration and neighborhood effects. A large literature in urban economics suggests that areas of more dense population and activity are more productive than are more sparsely settled and used areas; in other words, there are positive spillovers to dense development. Moreover, reclaiming despoiled land may displace the other uses and activities that sometimes become established in otherwise abandoned areas, such as drug use and crime.

To date, attempted or proposed efforts to estimate benefits of cleanup and revitalization of hazardous waste sites have relied on one of three different approaches: effect-by-effect modeling, stated preference techniques, and hedonic property valuation. The results of the different approaches are interesting both in their own right and for comparison with one another.[12] Other studies have made efforts to gather some quantitative information about the preservation of “greenfields” that might result from brownfields development. In the remainder of Section III, we explain each methodology and summarize the relevant empirical literature.

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[12] Note that there is no expectation that health and/or production approaches should give the same results as would hedonic analyses since the two approaches measure measure different, but sometimes overlapping, categories of welfare changes. For example, hedonic approaches would reflect the effects of cleanup and reuse that determine differences in property values between locations. Whereas a risk-assessment based study would measure the value of changes in human health risk.

Effect-by-Effect Modeling

One way to build up benefit estimates is to model the changes in physical quantities of hazardous materials to which affected communities are exposed, predict the consequences for human health, production, or ecological circumstances, and value the resulting changes in such endpoints.[13] A number of studies have applied this direct estimation technique.

Human health effects:

Applying a direct estimation approach to valuing changes in health outcomes involves four steps: identify toxics and pathways where they are found, identify the health risks associated with a toxic/pathway combination, estimate the size of the affected population and their pathway specific exposure, and estimate the willingness to pay for reduced exposure. To value the Clean Air Act, for example, analysts identified air pollutants with significant health effects, studied the inhalation exposure routes, and the associated mortality and morbidity risks. They then transferred from other sources benefit estimates on the value of reduced risks.[14]

To obtain health effect values for land cleanup programs using this methodology has the potential to be a much more complicated exercise, involving many more contaminants, exposure routes, and health endpoints. The wide variety of hazardous substances found at many contaminated sites make them especially complex, requiring assessment of a range of cancer and non-cancer health effects. Valuation must be considered anew for each site, diminishing the possibility of drawing general conclusions

[13] While it is conceivable to include amenity changes in effect-by-effect modeling, we are not familiar with any studies that have done so.
[14] See http://www.epa.gov/air/sect812/ for information on the Final Report to Congress on the Benefits and Costs of the Clean Air Act.

regarding site cleanup valuation methodology. The problem is exacerbated by a paucity of appropriate risk information. For many of the substances that are categorized as carcinogens, there is only information for exposures that result in 95% confidence that vulnerable segments of the population will be safe. For the non-carcinogenic substances, standard dose-response functions are generally not available. Instead, the available risk information is in reference doses and reference concentrations, the dosage or concentration that should not be exceeded in order to protect human health. These do not lend themselves to quantifying the health impacts of exceeding them. Epidemiological data for contaminated sites is also scarce. Typically there is not enough human exposure at a given site to produce reliable information about the risks posed by a particular contaminant.

We have identified only two published studies that have valued health effects of land clean up activities using this approach. Using risk information from NPL Records of Decision (RODs) signed between 1991 and 1992, Hamilton and Viscusi (1999) valued reductions in adult cancer risk due to remedial actions at 150 Superfund sites.[15] Their results highlight the heterogeneity of risks across sites. For their nonrandom sample of sites, they estimated 731 cancer cases avoided as a result of clean up efforts, with the benefits concentrated at a small number of sites: the mean cost per cancer case averted was $3 million for remediation, while the median cost per cancer case averted was $388 million. Lyberger et al. (1998) also focused on Superfund NPL sites. They attempted to quantify health effects of exposure to volatile organic compounds in drinking water for several endpoints associated with NPL sites and valued these effects using estimates of

[15] They also looked at hazard quotients for non-cancer risks but did not quantify health effects for any non-cancer endpoints. As with all other existing studies of the Superfund program, removal actions were ignored.

the costs of illness (COI). Distance from the site was a proxy for exposure. Their results suggest the total cost of these adverse health outcomes at 258 NPL sites to be around $405 million (2004 dollars) (US EPA, 2006b).

Two EPA efforts have proposed an effect-by-effect analysis of UST Cleanups and RCRA Subtitle C, as well as the Superfund Program (US EPA, 2000a, 2000b, 2005d). Both proposals, and a Superfund a hedonic analysis that we will discuss later, were reviewed by Science Advisory Board (SAB) Panels consisting largely of environmental economists (US EPA, 2002). The Superfund Benefits Analysis (SBA) is currently undergoing revisions that respond to its SAB Panel's review (US EPA, 2006a), but the UST/RCRA analysis was never conducted.

The SBA proposed applying to all Superfund site remediations the approach that Hamilton and Viscusi developed to estimate the value of adult cancer reductions. The SAB Panel was skeptical of this approach because of the highlighted heterogeneity of risk across sites. The SBA also proposed to estimate health benefits of reductions in four non-cancer health endpoints: acute accidents and injuries, birth defects, lead induced health effects (cognitive deficits and cardiovascular disease), and other chronic non-carcinogenic effects, following Lyberger et al. (1998). The UST/RCRA proposal included similar ideas for estimating social values of specific health risk reductions. The use of these approaches to value the aggregate health benefits of Superfund or of UST/RCRA was criticized by the SAB panels because of the sparse or inappropriate risk and exposure data.

The SBA SAB panel was less critical of the use of Lyberger et al.'s approach to illustrate some of the components of human health benefits of Superfund remediations.

They noted that relying only on epidemiological studies implies significant uncertainties about causation, mostly resulting from the assumption that proximity is an adequate proxy for exposure. Yet, because such studies are based on known effects to humans, they avoid the uncertainties associated with toxicological assumptions in exposure models.

Since Lyberger et al.'s study, new epidemiological evidence has been reported on birth defects. Thus, a 2006 revised SBA draft limits application of Lyberger's method to birth defects only (US EPA, 2006b). The analysis includes evaluation of lead, barium, and some solvents on the following health endpoints: IQ losses due to childhood lead exposure, birth defects due to exposure to some solvents, various adult illnesses (including premature mortality) due to adult exposure to lead, barium, and some solvents.[16] Preliminary estimates suggest a total avoided COI per year of $632 million (2004 dollars).

Turning to the UST/RCRA proposal, while its SAB review panel concluded that limiting estimation of cancer benefits to those from reductions in benzene exposure only was a reasonable simplification of the health effects for the UST program, it had serious reservations about the three contingent-valuation-based groundwater studies that were proposed for a benefits transfer approach (Edwards 1988; McClelland et al. 1992; Powell, Allee, and McLintock 1994). None of the studies directly considered benzene and in two of them respondents were told that there would be no health risks. The panel also suggested initially examining different approaches to estimating exposure for a few case study sites. Results would indicate whether simpler, more cost effective methods (with

[16] The revised SBA draft ignores contaminants such as cadmium, arsenic, pesticides, PCDs, and others. Ignored health effects include cancer, reproductive problems, neurodevelopmental effects not measured by IQ losses and others.

the possible addition of calibration factors), could replace more accurate full pathway modeling.

Ecological benefits:

To our knowledge, there are no estimates of the ecological or amenity benefits of land cleanup or reuse for any of the cleanup programs.[17] This is due in part to the paucity of data available for such analysis. Linkages between physical ecological data and data useful for economic analysis are still extremely difficult to model and even once these linkages can be established, choices on the economic valuation technique must still be made. In addition, there is generally very little information on ecological/ecosystem indicators being collected at hazardous waste site cleanups.[18]

Despite these barriers, the revised SBA draft provides some useful insights about the potential ecological benefits of remediation at Superfund sites. [19] The analysis gives the reader a good sense of the fraction of Superfund sites where ecological impacts appeared to be of no or minor concern versus the fraction where ecological impacts were a major concern. It also provides brief summaries of an illustrative sample of ecological risk assessment reports at several Superfund sites. Finally, the analysis makes an effort to get a sense of groundwater protection provided by Superfund remedial actions. They estimate that a total of 125 principle aquifers are potentially affected.

[17] Some production-function-related estimation has been attempted to link ecosystem services to the value of production (see, e. g., Acharya and Barbier 2001, or Pattanayak and Kramer 2002), and such techniques could potentially be adapted to the analogous context of land contamination and productive values.
[18] Similar barriers exist for estimating amenity benefits using an effect-by-effect modeling approach.
[19] The SAB panel criticized the orginal SBA proposal of using NRDA settlement to obtain estimates of interim lost use value of ecological services.

The draft RCRA/UST benefits framework also proposed to quantify certain ecosystem impacts. Using various physical fate and transport type models, they planned to estimate bio-physical type indicators such as the number of surface water contamination events avoided at UST sites, and the number of avoided contamination incidents or avoided contaminant concentrations in surface waters at RCRA sites. The SAB review panel suggested undertaking more quantitative landscape (GIS-based) analysis to derive indicators of preserved ecosystem benefits.

Stated Preference Studies

An important contribution of stated preference studies to the cleanup/reuse valuation question is the reporting of values on the willingness to pay for public goods which would not be reflected in market data. A second advantage is that stated preference surveys can ask respondents to consider hypothetical differences in circumstances. Thus they will be applicable to the estimation of a wide range of values, including nonuse/existence values.

Despite these potential advantages, few studies have relied on this method. In 1992, in anticipation of the RCRA Corrective Action RIA, EPA commissioned a contingent valuation study (McClelland et al. 1992) to estimate nonuse values from groundwater cleanup at RCRA sites. The SAB review of this study was critical of the survey design techniques used to try to separate use and nonuse values, primarily because the panel was not convinced the respondents understood what they were being asked to value. The panel acknowledged that their concerns were due in part to the requirement imposed by EPA on the researchers to develop a separate estimate of nonuse benefits.

More recently, Chattopadhyay et al. (2005) compared survey- and market-based approaches to valuing further cleanup of the partially remediated Waukegan Harbor Superfund site in Lake County, Illinois. They first applied a conjoint choice survey-based random utility model (RUM) to estimate household's willingness to pay for continued remediation of the site and then compared these results with those obtained from a hedonic study of 1996-2001 home sales of the same sample of households. The main pollutants on the Waukegan site are asbestos along the lakefront and PCB in the harbor, thus, the damages are primarily in beneficial use impairments such as fish consumption restrictions, beach closings, and restrictions on dredging operations. Instead of presenting categorical levels of various features, as is done in most conjoint choice surveys, the respondents were presented values of the features in the hypothetical choice option as percent higher or lower than the status quo home. The extent of changes in the harbor environmental conditions is presented as "additional pollution", no change, partial cleanup, and full cleanup. The measure employed in the hedonic analysis is the usual distance of the house to the harbor. Based on these measures of exposure, the results suggest that WTP values increase with environmental quality (e.g., from no change to partial to full cleanup) as expected in both models. Their estimates from the RUM model yield an aggregate WTP of $249 million (year 2000 dollars) for partial cleanup and $535 million for full cleanup. These estimates are comparable to the property value increases computed from the hedonic model. Chattopadhyay et al. (2005) calculate a $273 million gain from partial elimination of proximity effects, i.e., increasing distance from 2.45 to 5 miles from the site, and $594 million from full remediation, i.e., increasing distance from 2.45 to 8 miles from the site.

Finally, Alberini et al. (2006) are also currently using a conjoint choice survey based approach for valuing benefits from contaminated site remediation policies. Their focus is on investigating households' WTP for reductions in mortality risks resulting from cleanup activities on Superfund-equivalent type sites in Italy. Their preliminary estimates suggest a VSL of 5-6 million Euros for an immediate risk reduction (and about 1.26 million for a risk reduction occurring 20 years from now). They have not yet conducted a full benefit-cost analysis of the Italian cleanup program based on these results.

Hedonic Studies

A general framework

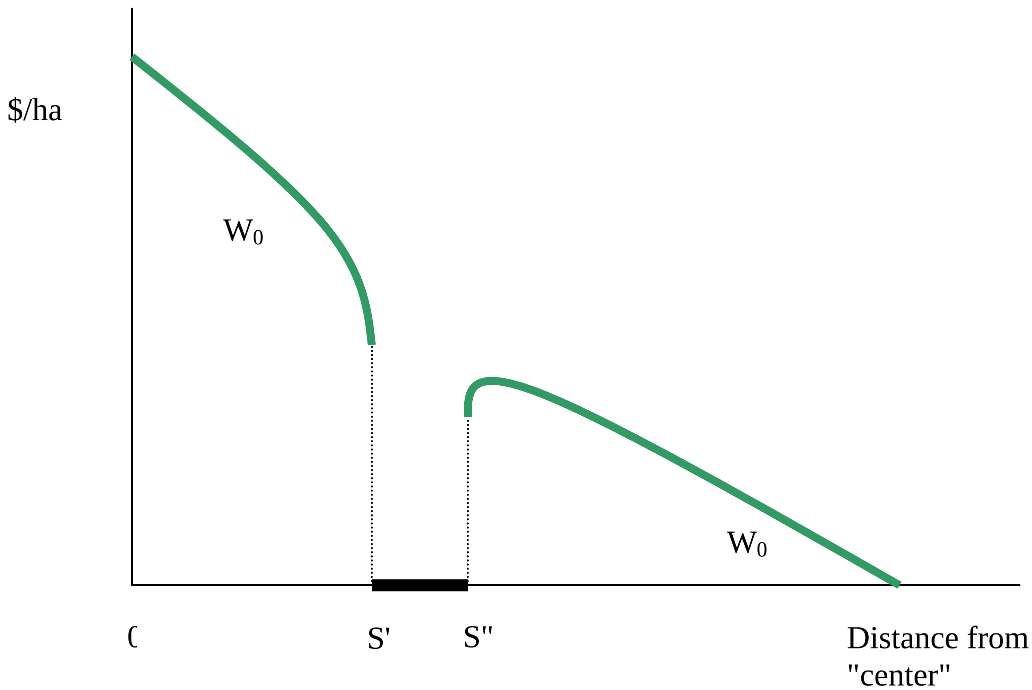
Perhaps the most natural way to measure the benefits of cleanup and reuse of a contaminated site may be through the market value of land. If a parcel of land is unusable when contaminated but commands a million dollars when cleaned up and resold, both common sense and economic theory support the conclusion that the cleanup effort was worth at least a million dollars (less whatever expenses must be incurred to make the property usable again).

Several issues can make this straightforward analysis difficult to implement, although it remains, in general, conceptually appropriate. First, one must observe transactions in order to record prices. Transactions in real estate markets can be relatively rare, especially when contamination is suspected. Second, it is a relatively easy thing to note that a property that would have had no value if left in its contaminated state commands a high price when restored to use. It is more difficult to infer how much of the increase in price of a property adjoining a contaminated site might be ascribed to the decontamination of a neighboring parcel.

There are a number of analytical models that may be used in modeling property values. Any sufficiently detailed to yield a realistic depiction of real-world property markets would become unwieldy, however, so we will employ a few simple diagrams to present our basic points.

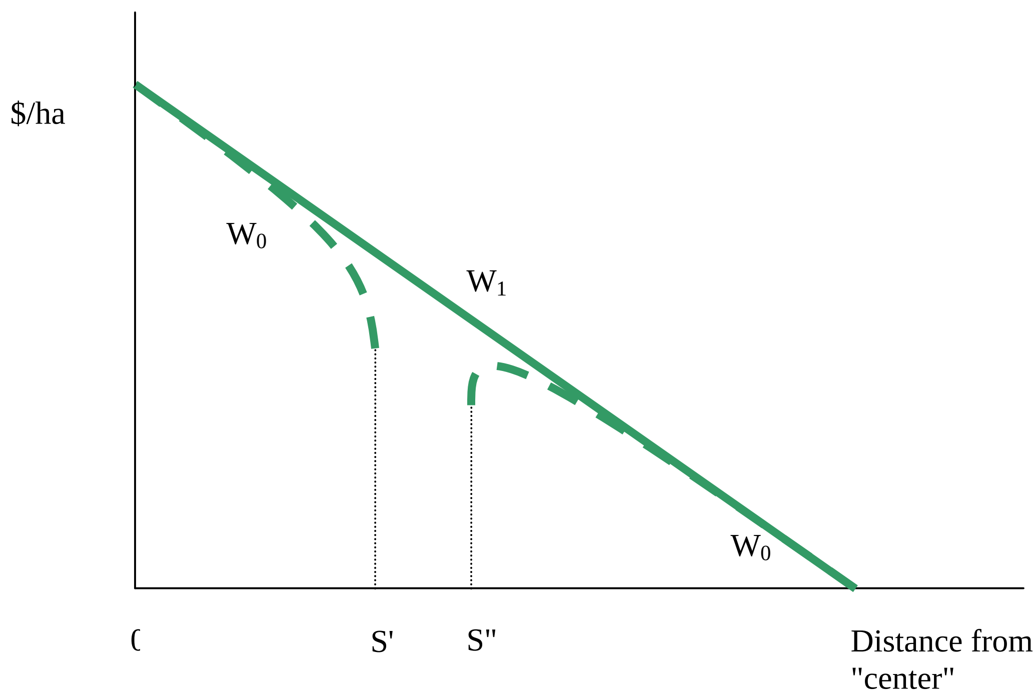
Let Figure 1 represent a cross-section of a two-dimensional landscape, where the curve labeled W_0 represents willingness to pay for land at any point on the landscape stretching from an urban center, labeled 0, to more distance locations. Two features are obvious from this representation. First, willingness to pay for land generally declines in distance from the center. Second, willingness to pay also declines with proximity to a contaminated zone, which we have labeled as the interval between *S'* and *S"*. We assume that willingness to pay for land between these boundary points is zero – this land is simply not used in the *status quo ante* – and that there are spillover effects associated with proximity to the contaminated area. These effects are depicted to be rather strong in Figure 1: willingness to pay actually increases over some interval to the right of *S"*, meaning that the effects of moving farther away from the source of contamination locally exceed those of moving farther from the center. This may not be a general proposition, however.

Figure 1.



Now suppose that land between *S'* and *S"* were reclaimed. In Figure 2, the new willingness to pay, W_1, is drawn presuming that original and new willingness to pay coincide after a certain distance away from the originally contaminated site. This implies two things. First, the externality is limited in its spatial scope; beyond a certain distance, it does not affect land values. Second, while land commands a higher price the closer it is to the urban center, there is a sense in which land per se does not appear to be scarce in Figure 2. Outside of the region originally affected by contamination, land prices are not affected by the restoration of the *S*" – *S*' additional units of land for use in the city. If we suppose that the boundary of the city were determined by the point at which W_0 intersects the horizontal axis,[20] this point remains unchanged between Figures 1 and 2.

Figure 2.



The situation depicted in Figure 2 might arise if land being reclaimed comprises a small addition to the total land available to a relatively large and mobile community. If relocation costs were relatively low, decontamination of land at an attractive location may bring new residents in. In the extreme case of costless relocation, however, such a model would assume that people must be indifferent among locations, i.e., that no one can realize any surplus from moving. In such circumstances all welfare changes arising

[20] We can define the intersection of the willingness-to-pay curve with the horizontal axis as the boundary of the city with little loss of generality. Rather than representing a willingness to pay of "zero", the horizontal axis might represent the opportunity cost of land for use in agriculture or forestry, activities for which location is much less crucial.

from land reclamation would accrue to owners of real estate. This is obviously an extreme assumption, but one worth bearing in mind if the analyst is focusing solely on changes in land values as a measure of welfare gains. Generally speaking, there will be other benefits (e. g., benefits to residents over and above those captured in land values, increased wages for local workers) that would not be fully captured in a hedonic property value analysis.

Another possibility that might underlie a pattern such as that in Figure 2 is that reclaiming the contaminated land affords new spillovers to all residents. A large literature documents and purports to explain the economies of agglomeration that presumably account for the emergence and importance of cities. "What can people be paying Manhattan or downtown Chicago rents for," Nobel Laureate Robert Lucas asked rhetorically, "if not to be near other people?" (quoted in Glaeser and Kahn 2004). If reclaiming land affords more people the opportunity to relocate closer to other people, all may achieve some spillover benefits. Such benefits can be, however, extremely difficult to estimate, especially if the analyst's intention is ultimately to trace them back to land decontamination.

Our point here is that we would want to consider carefully the reasons for which the willingness-to-pay-for-land curve[21] would shift in or out as land somewhere in the landscape is restored to use, as they will be important in determining the net welfare consequences of land cleanup and reuse. Also, we do not mean to suggest that this invariance of willingness to pay for land in general to the amount of land supplied in the city, as depicted in Figure 2, is a general proposition. In a later section we consider the

[21] We are choosing terms carefully. W_0 is willingness to pay for land at a particular distance from the urban center, *not* demand for land.

evidence that decontaminating brownfields would spare "greenfield" development at the edge of the city.

Hedonic Pricing Studies

Hedonic property models (HPM) attempt to estimate the marginal willingness to pay for a non-market housing amenity from property prices.[22] While the site and neighboring property values do not reflect all benefits of decontamination and reuse, they can capture perceived human health effects of cleanup, aesthetic or amenity benefits of cleanup and reuse, improved productivity associated with cleanup, and conceivably, even the spillovers that arise when the presence of one more productive activity creates the preconditions for another, as in the urban and "neighborhood effects" literatures (see, e.g., Durlauf (2004) for a survey of the latter).

Most HPM studies of contaminated sites use distance to the site as a proxy measure of the environmental good to be valued (e.g., McClelland et al., 1990; Michaels and Smith, 1990; Thayer et al., 1992; Chattopadhyay et al., 2005). In effect, "cleaning up" and "moving farther away" are assumed to be equivalent approaches for reducing exposure. As we have noted above, this can be problematic when "cleaning up" may also affect the property market equilibrium.

Even estimating benefits that *are* captured in property prices raises some vexing issues. Property that is known to be contaminated will, of course, command a lower price than will property that is believed to be safe. Property prices reflect the expected net present value of the stream of earnings (to be interpreted, for residential properties, as

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[22] See Boyle and Kiel (2001) for a recent review of HPM literature pertaining to environmental externalities.

actual or implied rental payments) arising from their subsequent use. Contaminated properties (or properties adjoining contaminated properties) will, then, command higher prices if it is expected they (or those adjoining them) will be cleaned up soon. It is also possible that property prices will decline in areas slated for cleanup. This could occur if it were not known beforehand that the area was contaminated. Or, it is possible that property prices would increase when contamination is officially "discovered". This might comprise a signal to residents who had suspected contamination that it is, in fact, there, but will soon be removed.[23] Accounting for the pattern of these price changes as a site passes through the various stages of the discovery, cleanup and reuse process are critical to assessing what can be counted as a benefit of cleanup and reuse activities. Although unfortunately no existing studies have data covering the entire time period between discovery of contamination and completed clean up of a site, some evidence of price effects associated with various stages of this process has emerged in the literature. We focus on panel data models which are better suited for estimating marginal willingness to pay for changes in the status of a site.[24] Virtually all the studies have focused on Superfund NPL sites.

Pre-and post-discovery effects. Aside from a few studies of lead smelter NPL sites (Dale et al., 1999; McCluskey and Rausser, 2003; McMillen and Thorsnes, 2000),

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[23] The problem is similar to that encountered in "event studies" of financial assets. One would expect stocks to rise on good, or fall on bad, news. This, however, presumes that what is "news" to the econometrician is "news" to the investor. If investors have learned earlier about factors affecting stock prices, they may already have gotten the "news", and may even interpret later signals differently than one might think at first: consider, for instance, the "good news" that the bad news wasn't as bad as expected.

[24] One recent cross-sectional study worthy of note, however, is Kaufman and Cloutier (2006). Unlike most of the HPM literature that focuses on cleanups of Superfund NPL sites, Kaufman and Cloutier look at remediation of Brownfield sites and attempt explicitly to estimate benefits resulting from reuse. They use results from brownfield proximity variables to determine the value of eliminating negative impacts of contamination and then the results from distance to a greenspace variable within the same housing market to get at the additional impact of converting to greenspace reuse.

most studies with data covering the time period prior to discovery of contamination or EPA involvement do not find a significant negative price effects associated with proximity to a hazardous waste site (e.g., Kohlhase, 1991; Kiel and Zabel, 2001; Michaels and Smith, 1990). The evidence of a price decline following discovery but before listing on the NPL is more robust (Kohlhase, 1991; McClelland et al., 1990; Hurd et al., 2002; Michaels and Smith, 1990; Mendelsohn et al., 1992; Kiel, 1995; Kiel and Zabel, 2001; Messer et al., 2006).[25]

Listing/"announcement" effect. The evidence on price patterns after a site listing or initial EPA involvement is mixed. This is partially due to data limitations that prevent researchers from sufficiently distinguishing between listing, information provision, response actions, and clean up activities. For example, Kohlhase (1991) claims to have found evidence that the listing of a site on the NPL causes home prices to decline, but her results could be misleading because of her inability to distinguish between discovery and listing for several of the sites in her study. McCluskey and Russer (2003) find evidence of a price decline immediately after NPL listing announcement, while Reichert (1997) finds little evidence of a price effect through NPL listing. Messer et al. (2006) find that prices of neighboring homes actually recover somewhat immediately after NPL listing of two of their study sites.

Focusing on commercial and industrial property markets, Ihlanfeldt and Taylor (2004) attempt to examine the impact of a contamination announcement separate from the NPL listing by limiting their sample to non-NPL sites listed in CERCLIS and/or the Georgia Hazardous Site Inventory (HSI). They examine effects for five land uses

[25] One exception is Reichert (1997), who finds little evidence of a price effect from discovery (1980) through proposal (1984) to listing (1986). His findings contradict much of the literature, but perhaps prior public knowledge of the landfill created a price effect pre-discovery.

separately (apartments, offices, retail, industrial, and vacant land) and find that the announcement/listing of sites causes significant declines in values of nearby commercial and industrial properties.[26]

Post-listing, price reversal/rebound effects. Empirical evidence on whether information provision and response actions reverse the decline in property values surrounding a contaminated site is generally inconclusive and incomplete. Studies that have data on potentially relevant time periods for sites that follow typical discovery to cleanup processes find a significant price reversal, or “rebound”, effect (McMillen and Thorsnes, 2000; Gayer et al., 2002; Hurd, 2002). McMillen and Thorsnes (2000), whose data cover pre-discovery to well after the start of remedial action, find the rebound effect to begin after listing. Gayer et al. (2002) find the release of the Remedial Investigation/Feasibility Study (RI/FS) to be the event that initiates the reversal of the price effect, but their data covers years well after sites were listed so other information about risks could have been made available prior to their sample period. Reichert (1997) only sees a price effect during and after the Record of Decision (ROD) is released.

Conversely, studies that cannot document a clear rebound effect tend to be complex instances with contentious histories in which lingering doubts remain about the condition of the site even after records of decision are issued. This describes the instances studied by Kiel and Zabel (2001), Kiel (1995), Dale et al. (1999), McCluskey and Rausser (2003a, 2003b), Schulze et al. (2004), and McCluskey and Rausser (2003a, 2003b). The findings of these studies suggest that stigma effects remain even after RODs

[26] Another recent study focusing on price effects for surrounding commercial and industrial property market only is Longo and Alberini (2006). They find that commercial and industrial property values are unaffected by proximity to (potentially) contaminated sites listed on or de-listed from CERCLIS or state registries in Baltimore.

are issued and cleanup begins. Messer et al. (2006), who study three prominent NPL sites, conclude that although promises of prompt cleanup may raise property values initially, costly litigation processes, cleanup delays, and increased media attention stigmatize areas and large property losses are sustained throughout the cleanup process.

Overall, existing HPM studies indicate that prices begin to decline after the discovery of contamination rather than the listing of a site on the NPL. Also, some results suggest that some rebounding does occur between listing and the start of remedial actions, as information on risks is made public and cleanup begins. Evidence on complete rebounding of prices to pre-discovery values is not sufficient at this point, partly because existing studies generally do not have data for post-cleanup years. The lack of hedonic pricing studies covering post-cleanup time periods also prevents us from shedding light on reuse related benefits. For example, it is unlikely that any agglomeration benefits resulting from the reclamation of contaminated land will be reflected in surrounding property values before reuse activity is underway (or at least prior to the designation of the type of use/reuse on the site).

Baseline Issue

Mixed evidence on the timing of the initial decline in property values points to one of the difficult issues in valuing the benefits of EPA's land cleanup programs: defining a baseline. The revised draft SBA contends that since price declines seem to be most apparent after the time of discovery, the baseline, or without Superfund, case should be pre-discovery. The SAB panel review of the Superfund analysis suggested that if the program itself caused a decrease in housing prices by spurring initial, unfounded beliefs about the extent of contamination, then the appropriate starting price for the benefits measure should be post-remedial investigation (when a ROD is issued and people are fully informed about the risks they face). No consensus has emerged on this issue from the literature.

A further complication that must be addressed in estimating benefits of the Superfund program is whether and how to account for removal actions. For Superfund removal actions, the "event window" is compressed relative to the data observation frequency, so all price effects might occur too quickly to be captured in "before" and "after" snapshots. Thus, all HPM studies focus on estimating benefits of the remediation part of the program only. This suggests that the baseline, or “without Superfund remediation program”, case may be after site identification (and initial removal actions), at the start of the NPL remediation pipeline of events.

Estimates in the literature

With the exception of Thayer et al. (1992) and Ihlanfeldt and Taylor (2004), all HPM studies mentioned thus far focus on estimating price effects of residential properties[27] surrounding Superfund NPL sites, using proximity to the nearest site as a measure of exposure.[28] Overall, price effects have been found to be rather localized, with the maximum distance at which an effect is found ranging from 0.57 to 6.2 miles from the site. Panel data studies generally find a maximum distance of 2 to 2.5 miles with a mean estimated price effect of 7.4% (Mendelson et al., 1992; Reichert 1997; Dale et al.,

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[27] These studies generally look at Single Occupancy Detached (SOD) homes only. A few include condominium sales too but effects are not found to be that different for these (Ihlanfeldt and Taylor, 2004).

[28] Gayer et al. (2000, 2002) use aggregated lifetime excess cancer risk estimates of neighborhood sites. The draft SBA noted that replicating this estimate of exposure on a nationwide basis would be too difficult, and not amenable to benefits transfer using the distance gradients.

1999; Kiel and Zabel, 2001).[29] Of these, Kiel and Zabel (2001) and Reichert (1997) estimate non-linear price effects and provide mean house price data so a non-linear percentage effect can be calculated as well. On average, they find a 14.5% effect for homes less than half a mile from the site, down to 3.1% effect for homes 2.5 miles from the site. Regarding commercial and industrial property market effects, Ihlanfeldt and Taylor (2004) estimate as much as $1 billion in total losses across five land uses, which is equal to approximately 10% of the total fair market value of all commercial and industrial properties within 1.5 miles of the 44 CERCLIS or Georgia HSI sites in their sample.

While the literature reviewed thus far has shed light on some price effects, they are all case studies and do not lend themselves easily to estimating benefits of the entire Superfund program. The revised draft SBA is the only attempted meta-hedonic study of the Program. The SBA proposes to apply a benefits transfer approach that uses static estimates of the price-distance gradient from HPM studies and data on housing near NPL sites to map them into aggregate benefits estimates for the entire Superfund program. The earlier RCRA/UST proposed benefits analysis had also suggested using benefits transfer techniques from Superfund hedonic studies of predicted reductions in housing prices. The SAB panel review of the RCRA/UST proposal concluded that as long as certain methodological issues were addressed, the HPM approach is a relatively straightforward way to get ball park estimates of benefits. However, the panel thought it was unclear whether transferring estimates from Superfund studies is appropriate for

[29] These studies tend to have longer panels, with data covering the late 1970s to the early 1990s. Using a shorter panel (1988-1993), Gayer, Hamilton, et al. (2002) find price effects to extend up to 4 miles from the site. All of these studies examine urban/suburban, non-Federal, former industrial or waste disposal sites on the NPL.

RCRA and UST sites.[30] The SAB panel review of the SBA draft also expressed concerns about using such an approach. Most existing HPM studies focus on smaller (non Federal) NPL sites, in areas of relatively high population densities. If these are not representative of the universe of sites, this creates benefits transfer problem.

The one recent study that has attempted to perform a broader analysis of the Superfund program is Greenstone and Gallagher (2005). This study is unique in that it provides a research design that could potentially address the problem of omitted variables bias, a potentially large problem with HPM studies (Atkinson and Crocker (1987) and Graves et al. (1988) both find evidence of this). They develop this design by focusing their attention on a feature of the initial NPL assignment process. After the passage of the Superfund legislation, the original 14,697 identified hazardous waste sites were narrowed down to the 690 most contaminated sites and each was assigned a Hazardous Rating Score (HRS). Due to budgetary concerns, however, the proposed list had to be reduced to 400, so only sites with HRS above 28.5 were placed on the original 1982 NPL.

Using data from the 690 proposed sites and instrumenting for NPL listing with an indicator of whether the HRS value was above the 28.5 cutoff, Greenstone and Gallagher find that NPL placement had little impact on the growth of property values in the census tract (over 1980-1990 or 1980-2000), relative to tracts with sites that narrowly missed placement on NPL. Their results are reasonably robust to a series of specification

[30] Only a couple of studies have examined the effect of UST leaks on residential properties (e.g., Simons et al., 1997, 1999). Simons et al. (1997) find a 17% reduction in prices for homes within one block or 300 feet of a leaking registered underground storage tank site.

checks[31], and the authors give two possible reasons for their findings. Either there is heterogeneity in individuals' valuation of risk associated with contaminated properties (i.e., people living near sites may just have lower WTP to avoid risks because of income differences or preference heterogeneity), or people have imperfect information on the health risks they face and an incomplete understanding of the benefits of cleanup.

It should be noted that some of their modeling assumptions could also be contributing to the lack of a significant price effect. For example, property values near sites that narrowly missed qualifying for the 1982 NPL will only serve as a valid counterfactual for the evolution of prices surrounding the final NPL sites if they have not been remediated since that time. It seems quite possible that if contamination remained a concern at these sites, that state or federal cleanup programs besides Superfund would step in. Also, less than 60% of the NPL sites in their sample (198 of the 332 final NPL sites) had received a construction complete designation or site deletion by the end of the study period (2000). If remaining risks are still dampening prices around sites where cleanups are still underway, then Greenstone and Gallagher's can not capture the full benefits of Superfund cleanups.

Asymmetric Information

Much of what we have discussed thus far concerns the reasons for which contaminated land would provide society with fewer valuable services than clean land, and the ways in which that lost value might be measured. Techniques for such measurements typically presume that large numbers of individuals (in stated preference

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[31] For example, using circles around sites instead of census tracts, looking at neighboring census tracts, only high-density areas, sites with groundwater pathway scores exceeding 28.5 and in areas with high well water usage rates.

approaches) or "the market" (in hedonic models) know the condition of land. However, problems arise when prospective buyers are unable to ascertain the condition of properties they contemplate purchasing. Welfare gains are realized when transactions occur between a seller who values an asset less than does its purchaser. However, a prospective buyer might assume that the seller is trying to sell because he knows something the buyer doesn't: that the good on offer isn't worth as much as the seller is asking for it. Such "markets for lemons" have been analyzed extensively in the general economics literature (beginning with Akerlof 1970), as well as the literature on property markets in particular (e. g., Boyd, et al., 1996; Gayer, et al., 2000). The possibility of such informational asymmetries constitutes an argument for public intervention in decontamination over and above the more common argument for correcting externalities.

Informational asymmetries and the designation of land as free of contamination are addressed by EPA's Brownfields Program. Both anecdotal accounts and academic studies (Lange and MacNeil 2004a, 2004b; Alberini et al. 2005; Wernstedt et al. 2006) document owners' and developers' concerns with actual and potential liability. While it is no surprise that responsible parties would regret being held liable for contamination, the larger problem revealed in these studies is that *potential*, as opposed to actual, liability prevents transactions.

Despite the considerable practical and academic interest in the topic, there appear to be fewer studies of the effects of informational asymmetries concerning potential contamination than there are of the effects of contamination itself. It can be difficult to distinguish between the two, however. Properties might command lower prices on average either because they really *are* contaminated or because they are just *suspected* of being contaminated. Existing hedonic studies might provide indirect evidence of information asymmetry effects. Theory predicts that when buyers do not know the attributes of a property for sale only "bad" properties would be offered and buyers will bid accordingly. After information is provided, however, both "good" and "bad" properties might be offered, buyers would be able to distinguish between types, and the average price of properties sold would reflect the mixture between types. In short, the average price of properties sold may increase after information was provided.

Studies focusing on the transaction rate[32] in potentially contaminated properties would provide more germane evidence concerning informational asymmetries. Comparatively few such studies have been conducted, however, and their results are somewhat mixed. Sementelli and Simons (1997) look at the transaction rate of properties on which underground storage tanks (USTs) are located.[33] Those that did not receive a "no further action letter" had a four percent transaction rate, in comparison to a ten percent rate among properties for commercial properties without USTs. However, the transaction rate for properties that *had* received a no further action letter was only 0.2 percent. This is surprising, as one might suppose that transactions would be more common once uncertainty was resolved.[34] Another study conducted by Simons and Sementelli with William Bowen (1999) finds a small but significant difference in transactions rates between sites with leaking USTs and other commercial sites.

[32] The transaction rate is the fraction of properties in a particular category whose ownership changes hands in a given year.
[33] See also the summary of this and other work in Longo and Alberini (2006), from which we have borrowed in preparing this review.
[34] A couple of explanations of this apparent paradox come to mind. First, it may be an open question as to whether uncertainty has, in fact, been removed. Second, no further action letters may be sought when a transaction is contemplated. If a letter is received near the time of a transaction, it may be unlikely that another will occur very soon afterward.

Conversely, Schoenbaum (2002) finds no significant relationship between contamination and land vacancy or turnover, though one would ideally look at the relationship between *suspected* contamination and transactions. While Schoenbaum (2002) finds brownfields had a lower propensity to sell in the 1980s during a time of increasingly stringent environmental regulations, the effect became insignificant in the 1990s. Apparently the property market had learned how to account for uncertainty and costs associated with pollution. This may not have been the same across all programs, however. Sigman (2005) compares the effects of state liability laws on development rates. Her results suggest that joint and several liability reduced development rates in 1990s relative to rates that would have obtained under strict liability. This ought not to be surprising in light of the relevant theory. Joint and several liability makes all parties to development responsible for the failings of any, exacerbating the problem of asymmetric information.

At least one author has remarked that "the market operates just as economic theory would suggest: Land sellers can and do lower prices sufficiently to compensate for the costs of remediation and the perceived risks of future cleanup" (Howland 2003). As the discussion above suggests, however, "economic theory" may admit more subtle distinctions. Proven contamination should result in a lower market-clearing price; suspected contamination may result in markets failing to clear at all. At least some authors (e.g. Boyd et al. 1996) suggest that the latter effect is more important.

Brown vs. Greenfields

Concern over the shrinkage and fragmentation of natural habitats, as well as "sprawl" – the low-density expansion of suburbs – has led various commentators to suggest that it will prove more environmentally benign to reuse lands that have already been employed in industry than to establish industry in hitherto unspoiled settings (see, e.g., Deason et al. 1999, and Glaeser and Kahn (2004) for a general discussion of sprawl in the context of urban economics). When industry reclaims "brownfields" it may reduce pressure for the conversion of more "greenfields". While this hypothesis is intuitively plausible, and there is some evidence to support it, it depends on the satisfaction of some special assumptions.

In Figure 2 above we supposed that restoring contaminated land to use would result in simply "restoring" the willingness to pay curve for urban land. Beyond a certain distance from the contaminated site the curve would be at the same level as before cleanup. Consequently, if prices are normalized so that the horizontal axis represents the opportunity cost of rural land, both the original and new willingness-to-pay curves would intersect the axis at the same point, labeled S_0 in Figure 2. This would measure the boundary of the city.

We might suspect that the more typical situation might be as depicted in Figure 3. While some local spillover effects may exist, and overall willingness to pay might be buoyed, the predominant effect of land reclamation would be to make urban land more plentiful in general, and willingness to pay in general declines. Potential purchasers are willing to pay less for any particular parcel because there are more parcels in general from which to choose. This reduces the pressure for expansion and the boundary of the city would move inward from S_0 to S_1.[35]

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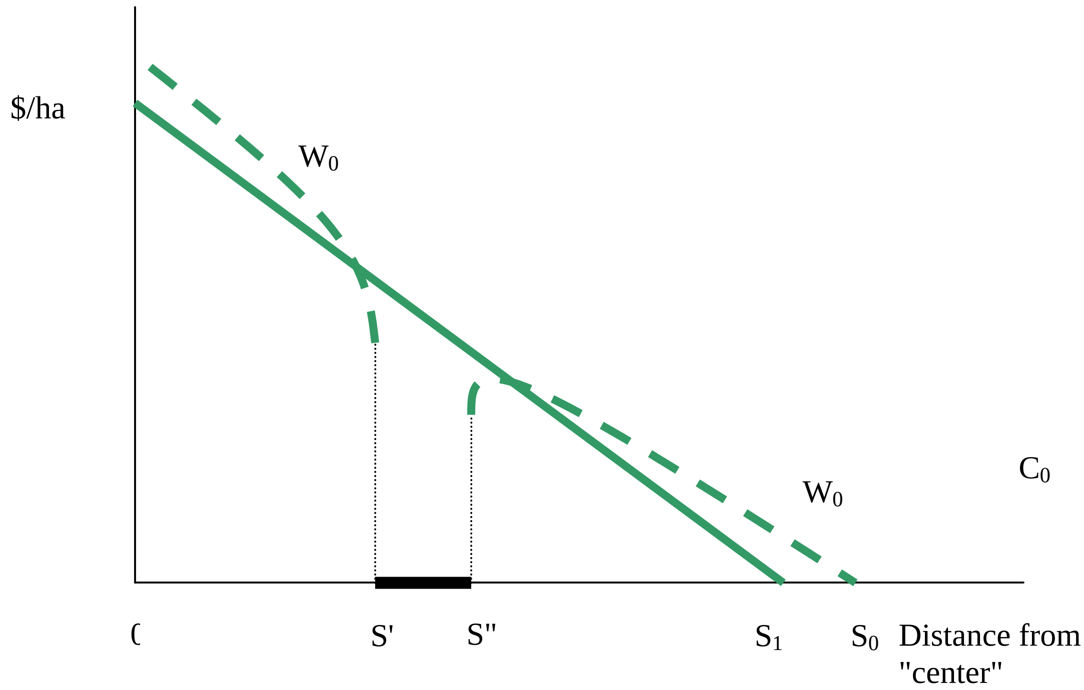
[35] The need to depict scenarios fairly simply limits us here. We cannot, for instance, include a time dimension in such simple figures. It seems unlikely that restoring brownfields to use would result in the *contraction* of existing cities. It would more likely slow their rate of growth.

Figure 3.



The empirical evidence on the land-saving effects of brownfield reclamation is limited. Two studies that have had visibility at EPA are Deason et al. (2001) and the Atlantic Steel Project XL benefits study. Both of these focus on estimating the reuse impacts of remediation of brownfield sites. The primary assumption driving the results of both studies is that absent clean up activities, development would have occurred on a nearby greenfield site.

Deason et al. (2001) estimated the land area required for various types of developments in inner city, brownfield areas versus suburban, greenfield areas. They then concluded that the amount of preserved greenspace resulting from the reuse activity is equal to the additional acres required for the same reuse activity in a greenfield. This metric, known as the "brownfield/greenfield offset," is based on the assumption that greenfield development uses more land than does brownfield redevelopment because of common planning regulatory factors in outlying areas.[36] Using data from 48 brownfield redevelopment projects across Baltimore, Burlington (VT), Lowell (MA), Richmond, Sacramento, and St. Louis areas, and published land regulations for 3 identified greenfield counterparts for each, Deason et al. found that, on average, each redeveloped brownfield acre would have required a minimum of 4.5 acres had the same project been located in a greenfield area.[37]

While it has been pioneering and widely cited, the Deason et al. study raises some questions. It implicitly assumes that the effects of brownfield redevelopment are small, in the sense that the availability of more land in the urban center does not affect market conditions or regulatory restrictions placed on land at the suburban fringe (see Wernstedt (2004) for a discussion of Deason et al's assumptions regarding the substitutability of urban and suburban development projects). Deason et al.'s offset ratios are based on current prices, land use practices, and regulations. If restoring brownfield land to productive use changes economic and political equilibria, the offset ratios might no longer be valid. If more land is made available at the center one consequence might be reduce further the opportunity cost of land at the suburban fringe and thus motivate a still larger offset ratio on properties that are developed away from the center. As Wernstedt

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[36] Common low-density regulations include building set back requirements, parking requirements, density requirements (maximum number of units per acre, FAR (floor to area ratio) limits), building height limits, landscaping and buffer zones.

[37] This is an average of the offset ratio computed for three different land use categories: 6.2 for industrial projects, 2.4 for commercial, and 5.6 for residential. The 4.5 ratio is skewed due in part to the influence of a few high outliers; the median ratios – 1.3, 1.7, 2.1 for industrial, commercial, residential, respectively – are all much lower than the corresponding means.

DeSousa (2002) uses a similar brownfield/greenfield offset approach to calculate "agricultural benefit" of reuse. He uses the average gross farm receipts to value the preservation of agricultural lands in urban peripheries resulting from reuse of urban lands and consequent reduction of development pressures on greenfields. The agricultural benefit of reuse is the (potential) production of crops on land that otherwise would have switched into nonagricultural use.

(2004) points out, Deason et al. does not provide sense of market demand for "equivalent" projects in greenfields and the degree of substitutability of developments in two areas.

Perhaps most problematically, the dynamics of urban expansion, which are composed of equal parts economic, political, and social considerations, are poorly understood. We do not have a clear understanding of when alternative growth centers arise (e.g., Yinger 1992, Henderson and Mitra 1996). If unreclaimed brownfields are partly to blame for the self-perpetuating rise of "fringe cities," the argument for reclaiming them might be stronger yet.

Another study investigating the effects of land reclamation on regional land use is the Atlantic Steel Project XL Brownfields benefits study (http://www.epa.gov/ProjectXL/atlantic/). EPA conducted three analyses: first, of regional transportation and air emissions impacts; second, of site level travel and air, open space, and impervious surface impacts; and third of local emissions "hot spot" impacts. The analysis used Atlanta's regional transportation model and EPA's MOBILE 5 emissions model and a new smart growth water assessment tool for estimating runoff (SG WATER) model for estimating water quality impacts.[38] It was assumed that Atlanta growth will continue for 20 yrs, and without redevelopment of the 138 acre Atlantic Steel site, more of the growth will go to outlying areas. The analysis compared the impacts from redevelopment of the urban Atlantic Steel site to three alternative locations. The

[38] Water quality impacts modeled include: total runoff volume, total suspended solids (TSS), phosphorus, and nitrogen loads (kg/yr)). EPA developed the SG WATER model because all existing models were deemed either too complex or lacked the flexibility needed to measure specific differences between different development patterns, site design, and location. For technical documentation for SG WATER see: US EPA, Development, Community, and Environment Division. SG WATER: Smart Growth Water Assessment Tool for Estimating Runoff, Technical Approach, March 2002.

brownfield/greenfield offset was computed to be 1.04 for the alternative urban perimeter site, and 8.2 for the alternative suburban and exurban locations.

IV. Conclusions and directions for further research

EPA programs addressing land cleanup and reuse are in need of accessible methodologies to assess their welfare effects. The need persists despite efforts on the part of EPA analysts and some academic researchers to develop reasonable benefit measures. Preliminary efforts have been directed at effect-by-effect modeling of social benefits, addressing health and ecological effects. Direct estimation of health benefits based on risk assessment data has been problematic. The wide variety of contaminants and lack of data on exposed populations, appropriate risk information, and WTP estimates for many health endpoints has limited the use of this method for obtaining measures of aggregate health benefits of EPA cleanup programs. Appropriate data on relevant ecological measures is also unavailable, although recently some insights have been gained by examining information about NPL sites where ecological considerations were important.

Stated preference techniques have been employed in a couple of instances but have yet to shed much light on broader benefits, including nonuse values, of cleanup or reuse. Hedonic pricing studies, by far the most common method used in the land cleanup context, although largely limited to NPL sites, have contributed some estimates of how early stages of the site identification and clean up process impact surrounding residential property values. However, evidence on the pattern of price effects is still rather inconclusive, and program-wide benefit estimates based on these (primarily case) studies are incomplete. Furthermore, unresolved practical issues with using hedonic methods in the context of land cleanup and reuse remain.

A few studies have gathered information about the extent to which property transactions might be depressed due to asymmetric information regarding land contamination. Results from these studies are inconclusive and the question as to whether reduced transactions might impose even larger social costs than reduced values at transactions that occur remains open.

Finally, preliminary estimates of the amount of green acres required to accomplish the same productivity as reused brownfield acres are available. However, the estimates are based on simple comparisons and do not, for example, account for changes in the demand for land at the suburban fringe that could result from greater availability of land in urban centers. More generally, understanding the tradeoff between brownfields and greenfields requires knowledge of the dynamics of urban expansion which currently is poorly understood.

In light of initial EPA efforts and the inconsistency of existing empirical estimates, a number of priorities for further research can be identified. It is still not evident that any one method, or combination of methods, stands out as better suited to the task of valuing the social benefits of land cleanup and reuse. Of course, different methods may be better suited to particular subsets of benefits (or costs), and the preferred valuation method may depend upon the nature, severity, timeline, or other attributes of more specific scenarios. For example, it is worth investigating whether risk assessment based modeling approaches could be used for estimating health benefits of less complex programs that deal with fewer contaminants (e.g., UST). An overall reassessment of the feasibility to better fate and transport pathway modeling is also warranted, and more research is needed in developing valid indicators of ecological and amenity benefits of cleanup.

Recent attempts at applying conjoint choice based techniques to the issue of land cleanup seem promising, but more research is needed to shed light on the practicability of using stated preference methods for measuring the wider range of cleanup and reuse benefits. Since revealed preference approaches such as hedonic pricing studies are simpler and less expensive to carry out than survey-based approaches, it is also important to think about where they have the most value and how they might be improved. For example, consensus should be reached on the appropriate baseline from which cleanup and reuse benefits are to be measured. Other practical issues (e.g., functional form of hedonics, data availability for post cleanup years, informational constraints, etc.) also require attention. To date, most case studies have focused on identification and remedial actions at Superfund NPL sites. If these sites are not representative of the universe of Superfund sites or other contaminated properties, then conducting benefits transfer from existing studies to value all NPL sites or other clean up programs will be problematic.

Finally, a multitude of other unanswered questions remain. How can one measure the value of facilitating transactions that might not have occurred in the presence of information asymmetries prior to site assessment and cleanup? Can economic theory shed more light on the extent of the often noted greenfield-saving aspect of land reuse? Can any existing methods be used for measuring the benefits of Superfund removal actions? Future research that targets these questions will help inform benefits analysis of cleanup and reuse programs at the EPA.

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