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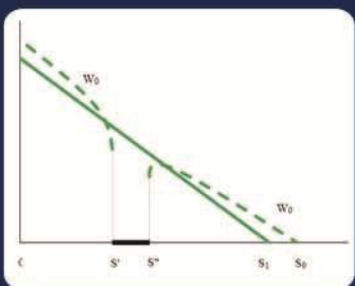
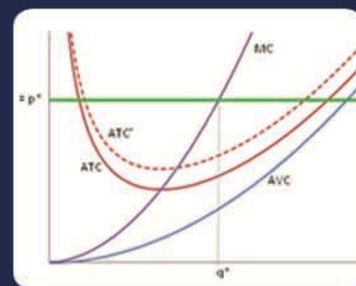
Handbook on the Benefits, Costs, and Impacts of Land Cleanup and Reuse





United States Environmental Protection Agency

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Office of Solid Waste and
Emergency Response

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Acronyms and Abbreviations

ACRES	Assessment, Cleanup and Redevelopment Exchange System
ASTM	American Society for Testing and Materials
ATC	average total cost
AVC	average variable cost
BCA	benefit-cost analysis
CCR	coal combustion residue
CERCLA	Comprehensive Emergency Response and Liability Act
CGE	computable general equilibrium
COI	cost of illness
CPA	Center for Program Analysis
DID	Difference in Difference
EIA	economic impact analysis
GAO	U.S. General Accounting Office
HEA	Habitat Equivalency Analysis
HSWA	Hazardous and Solid Waste Amendments
IV	instrumental variables
LUST	Leaking Underground Storage Tank
MC	marginal cost
NCEE	National Center for Environmental Economics
NPL	National Priorities List
NRD	Natural Resource Damage
OMB	Office of Management and Budget
OP	Office of Policy
OSWER	Office of Solid Waste and Emergency Response
OPA	Oil Pollution Act
OVB	omitted variable bias
PACE	Pollution Abatement Cost and Expenditures
PCB	Polychlorinated Biphenyl
RBCA	Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act

RD	Regression Discontinuity
REMI	Regional Economic Models, Inc.
RIA	regulatory impact analysis
ROD	Record of Decision
SP	stated preference
TRI	Toxics Release Inventory
UST	Underground Storage Tank
VCP	Voluntary Cleanup Program
VOC	volatile organic compound
VSL	value of statistical life
WTP	willingness to pay

ACKNOWLEDGMENTS[1]

This *Handbook* was developed by EPA's National Center for Environmental Economics (NCEE) in the Office of Policy (OP) in partnership with the Center for Program Analysis (CPA) within the Office of Solid Waste and Emergency Response (OSWER). Primary participants in its development were Heather Klemick, Robin Jenkins, Lura Matthews, Jared Creason, Elizabeth Kopits, Alex Marten, David Simpson, Patrick Walsh, and Kevin Haninger. Ed Chu, formerly with OSWER's CPA, provided ideas and guidance during early development of the *Handbook*.

Important sources for the *Handbook* include Science Advisory Board feedback to two recent OSWER benefits assessment proposals, as well as feedback from two recent workshops: "Estimating Community Economic Impacts from the Reuse of Contaminated Properties," held by NCEE, Resources for the Future, and Industrial Economics, Incorporated on February 26, 2004 in Washington, DC and "Methods for Estimating the Social Benefits of EPA Land Cleanup and Reuse Programs," held by NCEE and OSWER's Land Revitalization Office on September 28-29, 2006 in Arlington, Virginia.

The *Handbook* has benefited from careful review by multiple individuals. Comments on prior drafts were provided by economists in NCEE and by staff in OSWER, the Office of Environmental Justice, OP's former Smart Growth Office (now the Office of Sustainable Communities), and members of EPA's cross-Agency Economics Forum. Special thanks go out to the following individuals who provided comments: Alex Barron, Ann Ferris, Charles Griffiths, Kelly Maguire, Cynthia Morgan, Carl Pasurka, Nathalie Simon, Chris Moore, Ron Shadbegian, David Simpson, and Ann Wolverton of NCEE; Dan Hutch of OP's Smart Growth program; George Denning of the Office of Emergency Management; and Mark Eads of the Office of Resource Conservation and Recovery.

An external peer review panel provided invaluable suggestions for revising the *Handbook*, as well as highlighting key issues for future research. V. Kerry Smith (Arizona State University) chaired the panel, and the other members included H. Spencer Banzhaf (Georgia State University), Timothy Bartik (W.E. Upjohn Institute for Employment Research), Jan Brueckner (University of California, Irvine), William H. Desvousges (W.H. Desvousges & Associates, Inc.), Ted Gayer (Brookings Institution) and Nicolai Kuminoff (Arizona State University).

[1] Editor's Note: The version of this document posted on the internet was changed on Dec. 7, 2011 by adding Text Box 6.2 that had previously been erroneously omitted.

1 Introduction

Analysts need reliable methodologies to assess the economic effects of land cleanup and reuse. These economic effects include social benefits, social costs and a miscellaneous variety of economic impacts such as number of jobs or tax revenues.

This need persists despite targeted efforts by EPA to develop benefit and cost estimates. OSWER has undertaken two separate projects to develop methods for estimating the effects of its programs. The first effort proposed a framework and methods to estimate the benefits, costs and impacts of the Underground Storage Tank (UST) Program and the Resource Conservation and Recovery Act (RCRA) Subtitle C prevention and waste minimization program (U.S. EPA 2000a, b). A separate project obtained preliminary estimates and suggested methods to comprehensively assess the Superfund remedial program's benefits from 1980 to 2004 (U.S. EPA 2006b). Science Advisory Board panels evaluating both of these proposals highlighted the lack of appropriate data and sufficiently developed methodologies to obtain credible benefit estimates (U.S. EPA 2002a, 2006a).

This *Handbook* describes EPA's land cleanup[2] and reuse programs and outlines some of the unique aspects that have complicated efforts to develop suitable methods for estimating benefits. It clarifies the differences between types of economic analyses—specifically, benefit-cost and economic impact analyses. It discusses conceptual background, empirical challenges and practical suggestions for conducting these analyses, as well as summarizing new academic research in this area.

1.1 Purpose

While the *Guidelines for Preparing Economic Analyses* (U.S. EPA 2010e) (*EA Guidelines)* provides guidance on how best to perform benefit-cost and impact assessments generally, this *Handbook* targets the land cleanup and reuse scenario specifically. The *Handbook* has multiple objectives, including summarizing the theoretical and empirical literature. One aim is to provide recommendations for conducting economic analysis of land cleanup and reuse sites and programs when possible. The knowledge base for estimating the benefits, costs and impacts of land cleanup and reuse is still in its formative stages. Thus, another purpose of the *Handbook* is to provide a window into recent research and raise and clarify important questions that remain in the literature. The information provided in the *Handbook*, when used in conjunction with the *EA Guidelines*, should allow analysts to more fully characterize the net benefits and impacts of EPA policies and programs targeting land cleanup and reuse.

This *Handbook* has multiple goals, including:

- Describe the evolution of EPA land cleanup and reuse programs
- Distinguish between benefit-cost and economic impact analyses
- Discuss the unique aspects of land cleanup and reuse that complicate measuring social benefits, costs and impacts
- Outline benefit and cost categories relevant to land cleanup and reuse

[2] This *Handbook* uses the term "cleanup" loosely to refer to efforts to contain, remove, mitigate, or otherwise treat land contamination, recognizing that such efforts rarely, if ever, return land to a pristine condition.

- Introduce methods potentially useful for estimating benefits and costs of land cleanup and reuse
- Examine the strengths and weaknesses of these methods for different types of sites, programs and benefit categories
- Highlight recent academic research relevant to land cleanup benefit and cost estimation
- Identify gaps in the existing literature to spur new research
- Make recommendations for conducting benefit-cost analysis (BCA)
- Discuss important issues for land cleanup and reuse highlighted by economic impact analysis
- Offer guidance for conducting impact analysis

The *Handbook* discusses when relatively simple approaches to benefit, cost and impact estimation are appropriate, but it also highlights when more complex methods are needed. Such methods could require substantial staff, data and computing resources. As noted in the *EA Guidelines*, off-the-shelf data and models are rarely available, especially for environmental benefits assessment. In addition, a few sections of the *Handbook* provide the theoretical foundations necessary for interested analysts to understand the economics behind some of the empirical approaches.

The chapters that follow intend to provide technical assistance to analysts at the federal level when the state of knowledge is sufficient to justify practical recommendations.[3] The hope is that the framework for analysis and the methods presented will be useful at the state, regional and local levels as well. Several sections of the *Handbook*, including the discussion of the differences between economic impacts and social benefits and costs, should be a useful reference for policymakers and analysts regardless of jurisdictional scope.

Another key objective noted above is to summarize current relevant research. To that end, the *Handbook* cites several recent studies, including some unpublished literature, in the areas of property value models, stated preference (SP) approaches and general equilibrium analysis. While these studies might not yet be of direct use for policy analysis, they offer important considerations for economic analysis of land cleanup and reuse that can help analysts better interpret and apply established methods and results.

1.2 Background: From Cleanup to Reuse

As part of its mission to protect human health and the environment, EPA seeks to clean up and restore land contaminated by hazardous substances or land suspected of such contamination. Several laws provide EPA with the statutory authority to address contaminated sites. The 1980 Comprehensive Emergency Response and Liability Act (CERCLA), known as Superfund, addresses the cleanup of contaminated sites and emergency releases of hazardous substances. The 1984 Hazardous and Solid Waste Amendments to RCRA give EPA the authority to

[3] The *Handbook* does not seek to offer guidance about identifying cleanup and reuse options for contaminated sites, though other EPA and OSWER resources help to meet this need. For example, Principles for Greener Cleanups (http://www.epa.gov/oswer/greencleanups/principles.html) and the Green Remediation Best Management Practice Toolkit (http://www.clu-in.org/greenremediation/subtab_b1_materials.cfm) identify practices to reduce the environmental impacts of cleanup. A 2010 OSWER Directive on Superfund Reuse (U.S. EPA 2010a) addresses the role of anticipated land use in guiding the remediation process. It is recommended that interested readers consult these and other resources for more information about cleanup and reuse alternatives and their relative impacts on public health, the environment and community revitalization.

administer the Corrective Action Hazardous Waste Cleanup Program and the UST Program. The Small Business Liability Relief and Brownfields Revitalization Act (Brownfields Law) contains legal provisions for addressing brownfields—sites that are underutilized because of actual or suspected contamination. Many state, tribal and local programs and laws also address cleanup and redevelopment of contaminated or potentially contaminated sites.

Recently, EPA has recognized the need to move beyond cleanup to address the problem of potentially, previously or slightly contaminated land that is vacant or underutilized. Such sites provide less social benefit to their communities than if devoted to their "highest and best use." EPA addresses the future uses of these sites by facilitating their redevelopment. Linking the cleanup and reuse goals at the beginning of a project can make redevelopment more efficient than would otherwise be the case. To address this objective, EPA launched an Agency-wide Land Revitalization Initiative in 2004 that promoted the reuse of sites that have been cleaned up or investigated and declared safe for use. Many states and local governments have also turned their attention to the reuse of remediated sites.

Redevelopment of formerly contaminated land may occasionally provide a cost-effective way to address a wide range of environmental and economic concerns. In particular, redeveloping urban sites might enable reuse that exhibits some of the outcomes usually associated with "smart growth."[4] These outcomes could include, for example, reduced air pollution because workers do not need to commute as far. Or, reusing urban sites could reduce the demand for greenfield land elsewhere, thus preserving wildlife habitat and other ecosystem services.

Land reuse might also offer the possibility of synergies with other environmental programs. For example, EPA's RE-Powering America's Land Initiative encourages the installation of renewable energy generation on redeveloped land and mine sites, taking advantage of various state and federal renewable energy incentives.[5] Such synergies might arise because of improved access to roads or electrical grid infrastructure, resulting in lower costs than using a greenfield site. This *Handbook* does not address evaluating the benefits and costs arising from other environmental programs that may be implemented on a remediated site; it is usually appropriate to keep such benefits and costs separate to improve clarity and avoid double counting.

1.3 Need for Economic Analysis of Land Cleanup and Reuse Programs

An assessment of the benefits, costs and economic impacts of a cleanup or reuse scenario allows decision makers to carefully weigh the trade-offs associated with a particular project or policy. BCA provides a monetary assessment of changes in social well-being. In contrast, economic impact analysis (EIA) measures a variable set of changes in the economy that are of interest to policymakers, such as number of jobs. Each cleanup or reuse project or program is unique, and analyzing its specific economic effects is usually informative to policymakers.

[4] According to the Smart Growth Network, "In general, smart growth invests time, attention, and resources in restoring community and vitality to center cities and older suburbs. New smart growth is more town-centered, is transit and pedestrian oriented, and has a greater mix of housing, commercial and retail uses. It also preserves open space and many other environmental amenities." (http://www.smartgrowth.org/about/default.asp)

[5] http://www.epa.gov/renewableenergyland

Economic analysis of new and existing federal regulations is mandated by various executive orders and statutes. Executive Order 12866 requires assessment of the social benefits and costs of all major rules—those with an impact on the economy of at least $100 million. The Regulatory Right-to-Know Act established another important requirement in 2001, calling for federal agencies to submit estimates of the social benefits and costs of their major rules individually and of their programs in aggregate. More recently, Executive Order 13563 directs federal agencies to undertake retrospective analyses to improve the effectiveness and reduce the cost of existing regulations. In addition, economic analyses can be used to develop better measures or provide context for program evaluations conducted to fulfill other regulatory requirements.

At the state level, redevelopment proposals by private firms or state and local governments are sometimes required to include economic impact analysis. Some states, such as New Jersey, require a brief analysis of the principal economic impacts of proposed brownfield redevelopment projects, including employment, income and other commercial effects. In Oregon, economic analysis helps determine if cleanup and reuse projects are eligible to receive state financial assistance. Regional and local governments often carry out economic impact analyses of changes in employment and tax receipts. Thus, accessible and standardized methodology would be useful at various levels of government.

However, economics is only one of many perspectives that inform decision making regarding cleanup and reuse at EPA. Others include legal, ethical and political considerations; technical and institutional feasibility; and sustainability concerns. Depending on the specific program or policy under consideration, these other factors may weigh more or less relative to economics in the decision maker's pool of information.

1.4 Organization of the Handbook

Chapter 2 sets the stage for the *Handbook* by presenting background information on EPA and state land cleanup and reuse programs. Chapter 3 explains the differences between BCA and EIA. Chapter 4 introduces the issues specific to measuring the economic consequences of cleanup and reuse. It identifies unique aspects of land cleanup and reuse, such as the wide variability among sites and the potential for stigma due to imperfect information. Chapter 5 discusses the concepts of partial equilibrium and general equilibrium analysis, two different frameworks for estimating land cleanup and reuse benefits and costs. Potential benefits of cleanup and reuse and the methodologies used to measure them are presented in Chapter 6. Chapter 7 reviews approaches for estimating the costs of land cleanup. Chapter 8 turns to methods for measuring several categories of economic impacts. Chapter 9 poses key questions for future research.

Readers interested in assessing the value of potential ecological impacts associated with cleanup and reuse will find relevant discussions in several chapters. Section 6.1.2 outlines the types of ecological benefits that might result from cleanup and reuse, like improved recreation or aesthetics. Section 7.4.2 addresses short-term ecological damages like habitat disruption that could occur during cleanup, though green remediation approaches can help minimize these.

As already mentioned, cleaning up contaminated sites in urban settings could offset development that might have occurred in less populated areas, potentially achieving "smart growth" objectives. Benefits associated with urban reuse and methods to estimate a subset of them are identified in multiple subsections under Section 6.1.5 “Increased Land Productivity,” as well as in subsection 6.3.3.3 “Calculating Agglomeration and Greenfield-saving Benefits” and subsection 8.2.5.1 “Environmental Gentrification.”

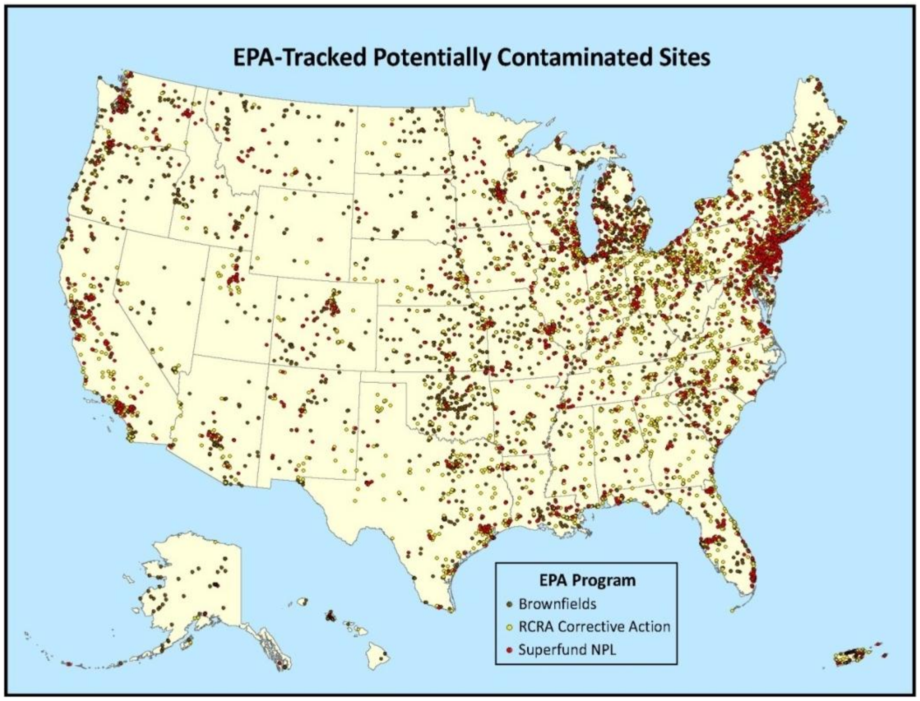
The *Handbook* includes an appendix that presents data sources of potential use to analysts estimating land cleanup and reuse benefits costs, and impacts.

2 EPA and State Cleanup Programs

Under authority of CERCLA, RCRA, and the Brownfields Law, EPA administers multiple cleanup programs to address contaminated land. Such land can taint nearby soil and ground water or spawn releases of toxic material through air and waterborne channels. EPA's cleanup programs address a variety of situations ranging from emergency releases requiring rapid response, to lengthy and complex remediations, to suspected contamination leading to vacant or inefficient use of land. While several of EPA's programs narrowly target cleanup, others mix in preventative measures. Many of them have recently incorporated components to encourage land reuse. This chapter briefly describes each EPA program with a substantial land cleanup component; specifically, the Superfund Emergency Response and Removal Program, the Superfund Remedial Program which administers the National Priorities List (NPL), RCRA Corrective Action, the UST Program, and the Brownfields Program. It also describes two recent EPA initiatives to improve consistency across cleanup programs and to highlight issues relevant to reuse.

Simultaneous with the evolution of the federal programs, the states developed their own programs outside of CERCLA and RCRA, though sometimes with financial or other assistance from the Brownfields Program or other federal sources. These state programs sometimes address sites not covered by a federal program, or they are preferred over a federal program because they assign greater control to state or private decision makers. Included is a general discussion of these state programs, which can be enforcement-based, such as state mini-Superfund programs, or incentive-based, such as state Brownfield or Voluntary Cleanup Programs (VCPs). The objective is to introduce the variety of cleanup programs typically in place throughout the states without providing a comprehensive inventory.

Figure 2.1 - EPA Cleanup Program Sites in the United States[6]



2.1 Federal Cleanup Programs

Each major federal EPA cleanup program was established by an act of Congress or an amendment to a prior act. The program descriptions are organized chronologically according to the relevant congressional acts and amendments followed by a description of two EPA initiatives.

EPA has an oversight role for approximately half a million sites encompassing more than 20 million acres, which translates into one percent of all land in the United States (U.S. EPA 2011a). Table 2.1 summarizes the number of sites and acres for four of EPA's five major programs. Figure 2.1 displays the locations of these sites.

Table 2.1 - Sites and Acres by EPA Cleanup Program

Program	Sites	Acres
Superfund Remedial	1,718	3,781,758
RCRA Corrective Action	3,747	17,946,593
Underground Storage Tanks	494,997	494,997
Brownfields	8,000	69,646
Total	**508,462**	**22,292,994**

Source: U.S. EPA (2011a)

[6] The map is compiled from three sources: The Assessment, Cleanup and Redevelopment Exchange System (ACRES), an online database for Brownfields; Cleanups in My Community, an online source for profiles of sites cleaned up under CERCLA and other programs; and finally, an internal EPA document describing RCRA Corrective Action sites. See the Appendix for links to ACRES and Cleanups in My Community.

2.1.1 CERCLA

Congress passed CERCLA, or the Superfund Law, in 1980.[7] It authorizes EPA to take action at contaminated sites that pose "a substantial endangerment to public health or welfare or the environment." The law includes a liability provision that assigns financial responsibility for cleanup to the parties responsible for contamination. Courts have interpreted CERCLA to impose retroactive, strict, joint and several liability on potentially responsible parties. Among other effects, the liability provisions deter potential future contamination.

CERCLA established two major categories of cleanup activities, both administered by EPA's Superfund Program. Removal activities involve the quick clean up of sites that pose imminent health risks. Due to their speedy nature, they are generally conducted following only a preliminary assessment to determine whether the site poses a potential risk to public health. EPA has completed more than 8,300 removal actions since the inception of the program, averaging more than 400 annually in recent years.[8] The majority of these removals have been conducted at sites that are *not* listed on the well-known Superfund NPL. Removal activities accounted for 19 percent of total Superfund expenditures from 2006 to 2010.

EPA's Emergency Response and Removal Program encompasses Superfund removal activities as well as responses to oil spills. The program also addresses radiological releases and large-scale national emergencies, including homeland security incidents. EPA conducts these cleanup activities by either funding response actions directly or overseeing and enforcing actions conducted by potentially responsible parties. The authority for this program originally came from the 1972 Clean Water Act, which targeted oil and hazardous substances. Authority was subsequently expanded or modified by CERCLA and the Oil Pollution Act (OPA) of 1990. OPA established an Oil Spill Liability Trust Fund, for example. In carrying out emergency responsibilities, the Emergency Response and Removal Program coordinates with other EPA programs, federal agencies such as the Coast Guard and Departments of Interior and Transportation, states, tribes and local governments (http://www.epa.gov/OEM/content/er_cleanup.htm).

The second type of Superfund cleanup activity is administered under the Remedial Program and consists of long-term cleanups of sites listed on the NPL. The Remedial Program generally undertakes more extensive risk assessments than the Emergency Response and 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 non-cancer and cancer risks are usually present. Exposure to ground water contamination often poses the most serious risks (Walker, Sadowitz, and Graham 1995). The Remedial Program accounted for 56 percent of total Superfund expenditures from 2006 to 2010. As of mid-2011, 1,637 sites had been placed on the NPL, with 1,101 (67 percent) of these in the final "construction complete" stage.[9] In practice, these sites often have removal as well as remedial

[7] CERCLA was amended in 1986 with the Superfund Amendments and Reauthorization Act (SARA). See http://www.epa.gov/superfund/policy/sara.htm for an overview of changes and additions to the program made by SARA.
[8] Data obtained from CERCLIS (http://www.epa.gov/enviro/facts/cerclis/search.html).
[9] http://www.epa.gov/superfund/sites/npl/index.htm

actions. Federal facilities listed on the NPL are managed separately by EPA's Federal Facilities Restoration and Reuse Office.[10]

2.1.2 The Hazardous and Solid Waste Amendments to RCRA

In 1984, as the Superfund program was carrying out removal and remedial actions at high risk sites that were often abandoned, a separate program was authorized by the Hazardous and Solid Waste Amendments (HSWA) to RCRA. While RCRA Subtitle C imposed cradle-to-grave standards for managing hazardous wastes, it did not address past contamination already present at facilities regulated by RCRA, including hazardous waste generators, transporters and disposers. The HSWA directly addressed these sites, and under its authority EPA established the Corrective Action Hazardous Waste Cleanup Program. Unlike Superfund sites, these sites generally have ongoing operations and readily identifiable operators that are compelled by the program to investigate and clean up their own hazardous releases, many of which occurred prior to RCRA.

The primary responsibility for implementing RCRA is delegated to individual states.[11] Since the Corrective Action Program is authorized by RCRA, it is primarily administered by states. Cleanup operations at Corrective Action sites are not separated into removals and remediation, as under Superfund. The Superfund Emergency Response and Removal Program typically handles releases on RCRA sites requiring emergency response. 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, which takes into account factors including contamination and potential exposures. More than 5,000 facilities have been identified as subject to RCRA Corrective Action. Of these, almost 2,000 have been identified as "high priority" and have been targeted for remediation first. A primary concern at many of these sites is ground water contamination. By 2008, "unacceptable human exposures" had been eliminated at 96 percent of the high priority sites. At 83 percent of these sites, there was evidence that ground water contamination was no longer spreading.[12]

Besides addressing past contamination at facilities regulated by RCRA, the 1984 HSWA also addressed the growing problem of petroleum and other hazardous substances leaking from USTs.[13] HSWA authorized EPA to establish a regulatory program that specifies technical requirements to prevent, detect and clean up UST releases and instituted financial responsibility requirements for UST owners and operators. Started in 1988, the UST Program also administers the Leaking Underground Storage Tank (LUST) Trust Fund, established by the 1986 Superfund Amendments and Reauthorization Act to pay for cleanups at sites where the owner or operator is unknown, unwilling or financially unable to take responsibility for the cleanup. As of 2010, cleanups had been completed at 401,874 of 494,997 confirmed releases from USTs.[14]

[10] The EPA Federal Facilities Restoration and Reuse Office works with its ten regional programs as well as the Department of Defense, the Department of Energy, and other federal entities to facilitate faster, more effective and less costly cleanup and reuse on federally-owned sites. One hundred and seventy-three federal facilities have been listed on the NPL. As of 2011, approximately 69 of these were in the "construction complete" phase of cleanup.
[11] EPA regulations set minimum standards, but states have the option of establishing their own higher standards.
[12] See http://www.epa.gov/osw/hazard/correctiveaction/eis/faqs.htm for more detailed information on RCRA Corrective Action Environmental Indicators.
[13] CERCLA specifically excludes sites contaminated by petroleum.
[14] See http://www.epa.gov/OUST/pubs/ustfacts.htm for more on UST program facts.

As with other federal programs under RCRA authority, states implement 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. Many states followed a three-tiered approach consistent with EPA risk assessment guidelines and procedures called Risk-Based Corrective Action (RBCA) that was developed by the American Society for Testing and Materials (ASTM) as an environmental cleanup standard. Some states have more stringent rules than the federal program.

2.1.3 The Brownfields Law

In 1995, EPA launched the Brownfields Initiative to address sites that were not contaminated enough to fall under existing programs, but where environmental concerns hindered reuse. In addition to posing possible health risks, these unused sites were often unsightly and occupied land with potential to invigorate surrounding communities. The U.S. General Accounting Office (GAO) estimated there were about 450,000 to one million such “brownfield” sites in the United States (2004).

During the program’s initial years, EPA provided seed money to local governments for brownfield pilot projects. In 2002, Congress passed the Brownfields Amendment to CERCLA (known as the Brownfields Law), which codified and expanded EPA’s existing initiative. The Brownfields Amendment defines a brownfield as “real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant” (HR 2869). The law also clarified Superfund liability protections for parties such as *bona fide* prospective purchasers, innocent landowners or contiguous property owners. These clarifications were intended to make it easier for contaminated properties to pass into productive uses.[15]

The Brownfields Program provides numerous categories of competitive grants: assessment, cleanup, revolving loan funds to capitalize loans used for cleanups, and job training. Since 1995, EPA has awarded 1,891 assessment grants totaling $444.6 million, 279 revolving loan fund grants totaling $273.5 million, and 751 cleanup grants totaling $140.8 million. Since passage of the Brownfields Law in 2002, approximately 60 percent of sites that both received an assessment grant (in fiscal years 2003-2008) and reported to EPA whether cleanup was required did not require clean up. 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. Different cleanup standards can be imposed on properties designated for residential, commercial or industrial use (U.S. EPA 2005a). In 2010, EPA began a pilot program to facilitate and encourage communities to consider the assessment, cleanup and reuse of brownfields within an area-wide context including properties surrounding the brownfield site.

2.1.4 The One Cleanup Program, the Land Revitalization Initiative, and the Integrated Cleanup Initiative

Recently, EPA has set out to improve consistency across cleanup programs and highlight issues relevant to reuse. In 2003, EPA announced the One Cleanup Program, which sought to improve the coordination, speed and effectiveness of cleanups. The program also aimed to generate

[15] See http://www.epa.gov/swerosps/bf/laws/

clearer and more useful information for communities and to improve measurement of cleanup performance results (U.S. EPA 2003a, b). To better establish the One Cleanup Program idea and extend concern to reuse of remediated sites, EPA established the Land Revitalization Initiative in 2004, a cross-program effort to emphasize that cleanup and reuse are mutually supportive goals and to encourage consideration of anticipated property reuse as an integral part of EPA's cleanup decisions. In 2010, EPA established the Integrated Cleanup Initiative which seeks to improve the Agency's land cleanup programs by, for example, integrating the Agency's land cleanup authorities to accelerate cleanups.

2.2 State Cleanup Programs

Many states have developed their own programs to undertake site remediation with associated state "mini-Superfunds."[16] These programs often handle sites that receive lower hazard rankings than those established for the federal NPL, but they sometimes manage sites eligible for the federal program. If parties responsible for the latter sites refuse to comply with state requirements, they can then be referred to EPA for possible action under the Superfund program (U.S. GAO 1998).

In addition to the enforcement-based, state mini-Superfund programs, states also routinely administer incentive-based brownfields or VCPs. These programs vary widely across states, but evolved in response to the widespread problem of under-used or vacant sites suspected of contamination. Incentives for participation generally include financial incentives such as assessment grants, cleanup grants, revolving loan funds and tax incentives. Often participation also provides some form of liability protection, an important motivation for responsible parties to participate.

There is a great deal of variation among state voluntary programs regarding the application of risk information and the management of long-term stewardship, for example. Many VCPs contain provisions that allow a risk-based approach to corrective action to tailor the cleanup remedy to the planned use of remediated land and save on costs. VCPs and other state cleanup programs continue to evolve to respond to changing land cleanup and reuse problems and to fill specific state needs.

[16] New Jersey's 1976 Spill Compensation and Control Act addressed cleanup of contaminated sites and *preceded* federal Superfund legislation (Williams and Matheny 1995, and Pendergrass 1998 cited in Jenkins, et al. 2009). For descriptions of the New York and Texas programs, see http://www.dec.ny.gov/chemical/8439.html and http://www.tceq.state.tx.us/remediation/superfund/assessment/index.html.

3 Benefit-Cost versus Economic Impact Analysis

Benefit-cost analysis (BCA) and economic impact analysis (EIA) provide different assessments of the economic effects of land cleanup and reuse. BCA is concerned with the change in overall well-being, while EIA examines the change in the allocation of resources and the nature of the reallocation. The reallocation could involve jobs, taxes, income and other economic variables of interest. These two types of analysis represent distinct paradigms for assessing measurable, economic consequences. A 2004 EPA workshop on the benefits of reusing remediated sites highlighted the importance of differentiating between benefit-cost and economic impact analyses, a distinction sometimes left unclear by studies of land cleanup and reuse (Probst and Wernstedt 2004).

Economic analysis can assess a regulation's efficiency, as well as other effects such as changes in the distribution of production, employment and resources across sectors, regions and groups of people. While BCA addresses the former concern, EIA focuses on the latter. Depending on the policy questions, one or the other analysis (or both) might offer more useful insights. For example, calculating the total change in society's welfare is important when examining the overall effect of a federal program. Assessing specific economic impacts like the number of new permanent jobs in a city and its increase in tax revenues may be of greater interest to a local government deciding whether to remediate and redevelop a particular site.

3.1 Benefit-Cost Analysis

BCA examines the net effect on social well-being of a policy or project by summing changes in dollar-denominated benefits and costs over all individuals. Dollars provide a common metric for aggregating over society different types of changes in well-being—usually at the national level—to represent the overall net change in well-being.[17] A policy has net benefits when the benefits are large enough so that the "winners" could hypothetically compensate the "losers" and remain at least as well off as before the policy change. The criterion is for hypothetical compensation—no actual compensation need take place. The efficient policy is the one that yields the maximum net benefit, regardless of the identity of the winners and losers.

In BCA, negative changes in individuals' well-being are labeled social costs, while positive changes are social benefits. Economists typically measure social benefits by estimating WTP—the maximum amount of money an individual would give up in exchange for an environmental improvement. Well-being is often referred to as welfare. Because the objective of BCA is to aggregate individual changes in welfare, each change in individual well-being should be counted just once, and ideally no changes should be omitted.

Even though changes in well-being are expressed in dollars, both market and non-market benefits and costs should be counted in a BCA. In fact, non-market benefits comprise many of the social benefits expected to stem from land cleanup, such as improved human health and neighborhood amenities. BCA can assess potential tradeoffs implied by different land uses; for example, commercial redevelopment might lead to higher business profits but fewer ecosystem

[17] Readers interested in more details on the conceptual basis for welfare analysis are referred to the "Economic Theory" Appendix in the *EA Guidelines* (U.S. EPA 2010e). See Zerbe and Bellas (2006) for a textbook presentation on the theory and practice of BCA.

benefits. Changes that cannot be monetized or even quantified are still important to include in a BCA as part of a qualitative discussion.

3.2 Economic Impact Analysis

EIA focuses on the change in the allocation of resources and the nature of the reallocation; such as whether the number of jobs in a region is significantly affected, profit levels of certain industries drop, or government tax revenues change. Significant resources can move into or out of an economic region, sector or demographic group in response to a policy change. Decision makers are often interested in reallocations affecting subgroups defined by geography (state, region, or municipality) or economic sector (specific industries, or government entities). While BCA does not address distributional considerations, EIA is useful for illuminating them.

Unlike BCA, EIA does not add changes in welfare across individuals to calculate a comprehensive measure of change in overall well-being. EIA is more flexible in that it can encompass a variety of impact categories and metrics, such as jobs, prices, output quantities or housing availability. Changes in the amount and distribution of these indicators might be delineated in dollars or other non-monetary units, such as employment rates. Effects that are considered transfers in BCA might be counted positively or negatively in EIA. However, only market-based impacts are typically included; non-market effects such as ecosystem services are rarely counted (Watson et al. 2007). In addition, EIA does not consider the opportunity cost of resources used in carrying out the policy outside of the area or group under study.

To illustrate what an EIA entails, consider a local government curious about how cleanup and reuse of a contaminated parcel might affect the local economy. To inform this government, an analyst might gather information about the net increase in temporary and permanent jobs associated with the project, the net change in property and sales taxes, and the closeness of fit between the new jobs and the skills of the local unemployed workforce. In short, any useful information regarding the economic effects of the project is eligible for inclusion in an EIA. The specific outputs of an EIA might also depend on the economic models available to the analyst.

In some cases, EIA data might be retrievable from the information gathered for a BCA. Chapter 9 in the *EA Guidelines* (U.S. EPA 2010e), which addresses economic impact analysis, recommends consistency in assumptions and methods between BCA and EIA whenever feasible.

Besides EIA, there are also other types of distributional analysis that assess how the effects of a policy are spread across different demographic groups. Equity assessment or environmental justice analysis focuses on the distribution of effects across individuals and households, or groups of particular concern such as children or historically disadvantaged low-income or minority communities. Chapter 8 of the *Handbook* goes over methods for EIA and briefly addresses equity assessment and environmental justice analysis.[18]

[18] The *EA Guidelines* suggests that an EIA be used to examine the distributional impacts affecting winners and losers resulting from a policy, while it advocates an equity assessment or environmental justice analysis to assess the consequences for particular disadvantaged groups. Chapters 9 and 10 of the *EA Guidelines* provide more discussion of these types of analysis.

3.3 Comparing BCA and EIA

Table 3.1 summarizes the distinctions between social benefits, social costs and economic impacts, as well as BCA and EIA. The measures of economic changes used in BCA can overlap with those used in EIA, or they might differ because of their focus on different geographic scales and types of effects. For example, a project to clean up and restore a contaminated site hosting a threatened species will generate social benefits if the American public derives existence value from the species, but local economic impacts could be negligible if no jobs are created or lost and property prices are unaffected. On the contrary, a business that relocates from outside the region to a project site can generate positive economic impacts for the host community through increased jobs and revenues, but entail little net social benefit for the nation if these jobs and revenues have simply moved from one locality to another with minimal improvement in the productivity of workers or other relocated resources. While EIA can include more types of impact categories than BCA, it does not attempt to be exhaustive in measuring the net welfare change across all individuals.

Table 3.1 - Definition of Economic Analysis Terms

Social Benefit	An improvement in well-being. Social benefits include both market and non-market effects.
Social Cost	A decline in well-being, including both market and non-market effects.
Benefit-Cost Analysis	An analysis that measures net changes in social welfare associated with a policy. This type of analysis includes both market and non-market effects and accounts for opportunity costs.
Economic Impact	A change in economic activity or allocation of resources affecting an industry, region or other segment of society.
Economic Impact Analysis	An analysis that examines the net changes in economic activity and distribution of resources resulting from a policy, focusing on market effects.

Adapted from Watson et al. 2007.

Geographic scale is an important distinction between BCA and EIA in practice, though in theory either type of analysis can be carried out at any scale. BCA need not only apply at the federal level; it can also include all market and non-market effects to examine net benefits within a region, state or other geographic entity. Such an analysis could be very insightful for regional policymakers.

Both BCA and EIA are typically included in Regulatory Impact Assessments of major federal regulations. However, policymakers might sometimes focus on one approach or another, depending on their specific objectives and the program in question.[19] EIA is usually chosen as the analytic approach in regional or sectoral analysis or when distributional concerns are prominent. For instance, economic disadvantage is one criterion for receiving a grant from the Brownfields Program. EIA or equity assessment present approaches for understanding the

[19] The varying perspectives of analysts in different types of agencies or departments help explain their preferences for different approaches as well (Boardman, Vining, and Waters 1993). For instance, someone in a finance or treasury department could be more concerned with government expenditures and tax receipts than diffusion of social benefits. On the other hand, an employee of a local or regional economic development agency is more likely to focus on job creation and new business revenue. This individual might view expenditures on development projects as desirable economic impacts and not take into account that they are a social cost.

distributional consequences of such grants. Federal programs facilitating regional objectives could also find EIA helpful.

3.3.1 Jobs and Wages

Jobs created in the course of cleanup and reuse activities offer one example of the differences between EIA and BCA. The number of jobs is often reported as an important metric in an EIA. More relevant to BCA is whether the wages associated with the new jobs might count as social costs or benefits, which depends on the context and the geographic scale of analysis. Determining whether cleanup and reuse has job impacts and how the social value of those impacts should be measured are two conceptually distinct issues.

When considering job impacts, the first issue analysts must confront is whether cleanup and reuse results in a net change in employment in the economy at the geographic scale of interest. Even if labor is utilized at a particular site because of a remediation or reuse activity, it is important to consider whether those workers would have been employed in another position absent of this project. As is true for all benefits, costs and impacts, it is important to measure jobs relative to a baseline of what would have happened without the cleanup and reuse project.

To address this issue, it is not solely the employment impacts directly related to the site's remediation and reuse that need to be considered, but also the larger net effect on the labor market. Under conditions of full employment, the labor market is considered to be at equilibrium, with all workers willing to work at the prevailing market wage able to find employment. In this case, labor employed in a remediation and redevelopment project represents the reallocation of labor among sectors and/or regions of the economy and not a net change in employment. If the labor market is not at full employment, there is the potential for cleanup and reuse to result in the hiring of previously idle labor resources. This occurs through previously unemployed workers being hired directly at the site or through a reallocation of workers to uses at the site which in turn creates vacancies elsewhere that are filled by unemployed workers.

It is important for analysts to measure the net employment impacts at the appropriate geographic scale. For local EIAs, net local employment impacts may be the relevant measure. Bartik (1991) presents a detailed look at models that can link effects on local employment growth to local unemployment rates. For analyses of national programs or projects, it may be more appropriate to focus on net national employment impacts. Section 8.1 presents considerations for estimating the net employment impacts of remediation and reuse projects at different geographic scales.

Turning to the second issue of the social value of jobs created as a result of cleanup or reuse, labor used during site cleanup, redevelopment or reuse generates social benefits by producing goods and services valued by society (including improved environmental quality, in the case of cleanup jobs). However, this labor imposes a cost on society equal to the value of the labor's alternative use absent the redevelopment, or in other words, the opportunity cost of labor. In an economy or region experiencing full employment, economists typically assume that the opportunity cost of a worker's labor is equal to the wages he or she earns. The rationale is that the wages earned are approximately equal to the value of the worker's output at an alternative job. Thus, in conditions of full employment, wages are a measure of spending on labor and are considered costs rather than benefits in a BCA (Boardman et al. 2011). This is the typical case.[20]

An exception to the standard assumption that wages represent the opportunity cost of labor arises when workers cannot earn similar wages at alternative employment (Haveman and Farrow 2011, Haveman and Margolis 1983). This may be the case in labor markets with structural unemployment, where some workers face limited opportunities even over the long-term.[21]

The opportunity cost of time for structurally unemployed workers is likely to be lower than the new wage, since earnings would otherwise be zero. Still, the value of an unemployed individual's time could be greater than zero, as he or she may be engaged in productive activities outside of the market such as child care, home maintenance, volunteering or leisure (Zerbe and Bellas 2006). Understanding the opportunity cost of labor for the unemployed is a difficult task as it is conditional upon characteristics specific to the individual (e.g., demographics, education, and length of current unemployment spell) as well as the local labor market, including the rate of unemployment.

Empirical evidence generally supports the hypothesis that an increase in the local unemployment rate or the duration of unemployment lowers the wage at which people are willing to work (Jones 1988, Kasper 1967, Kiefer and Neumann 1979, Stephenson 1976, Bartik 1991). However, these studies do not provide guidance for how to translate their results into specific estimates useful for policy analysis. Because there is no consensus in the literature about the average opportunity cost of labor under long-term unemployment, analysts are encouraged to consider multiple values between zero and the new wage rate to demonstrate a range of possible outcomes.[22] Boardman et al. (2011) provides a discussion of additional approaches to handling uncertainty over an unemployed worker's unobserved opportunity cost of time.

Newly employed workers might not be the only beneficiaries from reduced unemployment. Creating positions for the unemployed can also lead to positive externalities like reduced crime (Zerbe and Bellas 2006). While recent empirical studies have found the relationship between unemployment and property crime to be both positive and statistically significant (Corman and Mocan 2005, Papps and Winkleman 2000, Lin 2008), no studies to date have quantified the social benefits from positive externalities related to employment.

In practice, land cleanup and reuse activities will put to work a mix of employed and unemployed applicants, and predicting this mix for a specific project is difficult. A study by Bartik (1991, 1993) found that six out of every 10 new jobs were filled by local unemployed or workers otherwise out of the labor force in the short run, but these effects faded over time.

[20] Even though spending on labor is a cost within the framework of benefit cost analysis, workers who accept the new job opportunities view them as beneficial.
[21] Unemployed workers can fall into at least three categories: frictional unemployment occurs when workers are temporarily between jobs, cyclical unemployment is due to the overall economy's regular movement through recessions and expansions, and structural unemployment is long term and occurs when workers' characteristics—for example, geographic location or job skills—are not aligned well with labor demand. In this section, focus is placed on structural unemployment. While the theoretical concepts may also apply to cyclical employment, these methods are substantially harder to implement in cases of shorter term unemployment as the analyst must define a baseline that predicts when these individuals would have been expected to gain employment absent the project.
[22] EPA is currently developing an appendix to the *EA Guidelines* that will address how to account for the value of unemployed labor in BCA.

Haveman and Krutilla (1967, 1968) and Haveman and Margolis (1983) developed a series of labor response functions that mapped the unemployment rate for a profession to the probability that an unemployed worker would be hired if a new job was created in that field. The authors used linear and semi-logarithmic functions calibrated to have a zero probability of hiring the unemployed when the profession is at full employment and a probability of one at an unemployment rate of 25 percent. The general applicability of this approach has yet to be fully established, as a case study by Epp (1979) found that the Haveman-Krutilla labor response functions substantially overestimated the number of unemployed workers hired.

In sum, land cleanup and reuse can create employment opportunities, but it is critical to measure the net change in jobs at the appropriate geographic scale, rather than focusing only on direct on-site jobs. In addition, putting unemployed people to work can lower the social costs (raise the net benefits) of a cleanup or reuse project. Haveman and Farrow (2011) suggested that the surplus created by putting an unemployed individual to work should be accounted for in a BCA. BCA should also consider any additional externalities associated with reducing unemployment in the community. In labor markets without long-term unemployment, no adjustment should be made.

Alternatively, analysts might consider wages as benefits if their analysis focuses on a local or regional scale but an entity outside the region of analysis, such as the federal government, funds the new positions. In this case, the wages represent a social benefit to the region under study, but this benefit is balanced by a cost incurred outside of the region. It is generally not appropriate to count wages, or labor expenses, as benefits when conducting a BCA at the national level, except in the special case described above involving increases in net national employment.

3.4 SUMMARY

BCA is recommended to assess the net benefits of a policy, program or project. EIA is appropriate to gauge how resource reallocations might affect a specific locality, industry or other specific subpopulation. Often, EIA data might be retrievable from the information gathered for a BCA. If both analyses are being conducted, EIA should use the same assumptions and methods as BCA whenever appropriate. Most importantly, an EIA should not be interpreted as a measure of the net social benefits of a policy; its value is limited in scope to distributional consequences.

4 Special Considerations for Evaluating Land Cleanup and Reuse

This chapter introduces concepts and concerns unique to analyzing land cleanup and reuse. Evaluation of these activities presents several distinct issues from those that arise in the context of air or water pollution. Land is typically considered to be a private good, although contaminants can migrate to nearby properties and cause external costs. Imperfect information, stigma and liability rules can dampen transaction rates and values of contaminated land and nearby properties, potentially leading to inefficiencies.

In addition, the persistent stock and/or slow moving flow of hazardous substances give rise to unique spatial and temporal issues. While air and water regulations often require reductions in a flow of pollution from ongoing production activities, land cleanup efforts address stocks of contaminants generated by actions from the past. Also unique to land contamination is the wide diversity of contaminants, affected media and site characteristics which leads to a site-by-site evaluation of the question, “How clean is clean?” A final special consideration is that land cleanup can enlarge the supply of developable land and allow for increased productivity at the remediated site.

Many of these issues have methodological implications for assessing the benefits, costs and impacts of land cleanup and reuse, which will be addressed in subsequent chapters.

4.1 Is Land Contamination a Market Failure?

Two types of market failure can arise from land contamination. The first involves health and environmental externalities caused by land pollutants. The second stems from imperfect information and potentially high costs of property transactions. Poor information about a contaminated site or its effect on nearby properties, stigma and concern by property market participants over the potential effect of liability rules can all discourage transactions that could increase the productive capacity of vacant or underused land.

4.1.1 Health and Environmental Externalities

Land is typically considered to be a private good. It is both excludable and rival—access is easily restricted and use of the site generally precludes other simultaneous uses. In contrast to freely-blowing air or downstream-flowing surface water, land is stationary. While a casual observer might think that a stock of pollution generated by a landowner and contained within a parcel presents no market failure necessitating a correction, a closer look reveals a more complex situation at many contaminated sites.

A stock of contaminants on privately owned land can generate a slow-moving flow of pollutants that pose a negative externality to adjoining properties and beyond. Containment vessels can deteriorate, releasing pollution into air, surface water, ground water or soil. Indeed, many negative health consequences of contaminated land stem from human exposure to toxins in the air or water beyond the boundaries of the property. Even capped or fenced sites can pollute adjoining parcels or larger areas over time. Workers, trespassers and wildlife making on-site contact with pollutants are also potential victims of land contamination. Land cleanup programs attempt to reduce these on- and off-site externalities to protect public health and the environment.

4.1.2 Imperfect Information and Stigma

Contamination that does not migrate off-site might not constitute a market failure if information on the damages to the environment exists and is clear and accessible to the public. Property markets can still result in efficient outcomes—buyers aware of pollution revise their bids accordingly and sellers make efforts to avoid contaminating land in the first place, so as to not diminish its market value. Coasian principals suggest that even contaminants leaked off-site may not necessarily interfere with efficient property markets—if all parties have full information, act in cohesion, and can agree on compensation for damages or reductions in pollution (Coase 1960). Not surprisingly, these conditions typically do not prevail. Information issues in particular pose a special concern.

In practice, contaminated or potentially contaminated sites are often essentially excluded from property markets. Properties that could be productive can remain vacant or under-used for lengthy periods, causing social welfare losses. A statistic from the EPA Brownfields Program illustrates this point – of properties for which assessment and reporting was completed, approximately 60 percent did not require further cleanup action. Despite the eventual discovery that these sites did not pose actionable risk, lack of adequate information about their contamination status or the nature of the potential risks posed prior to assessment might have been preventing sale and/or reuse.

Markets for contaminated properties can fail to clear for many reasons. Poor or asymmetric information about potential contamination can lead to underuse of un-assessed sites. On the supply side, property owners might hold onto potentially contaminated properties to avoid facing cleanup costs or liabilities that could be revealed during or after redevelopment, a practice termed “mothballing” (Greenberg, Downton and Mayer 2003). Owners face uncertainty over the existence or extent of contamination, the cost of its cleanup, and who will be responsible for covering the expense (Kunreuther and Slovic 2001).

Even if owners do wish to sell, they might be unable to find willing buyers. Potential purchasers can be unwilling to conduct or consider a property transaction even when technical information suggests that the benefits of cleaning up and reusing a parcel outweigh expected costs. When this is the case, the land can be described as having “stigma,” a situation in which perceived risks are greater than technical risks, or in which benefits versus costs are not the deciding factor (Kunreuther and Slovic 2001, Fischhoff 2001).[23]

Risks that are unfamiliar or poorly understood may be approached with greater caution and thus associated with greater stigma than familiar, well understood risks. Research suggests that risk perception rises with risk characteristics like uncontrollability, effect on future generations, and delay in manifestation (Slovic 1987). Contaminated land often exhibits such traits. Sites may remain stigmatized even after cleanup efforts are complete. Such persistent stigma might cause sites to remain undervalued or underused.

[23] Kunreuther and Slovic (2001) do not provide a clear definition of stigma but in describing it they state, “In many instances we sense that the social and economic response is exaggerated, even unwarranted, leading to impacts far more serious than the initial threat.” Fischhoff provides a definition, “A stigmatized act is unacceptable whatever the associated benefits. If deciding what to do involves any cost-benefit calculus, then the resulting choice is not stigma driven.”

Imperfect information and stigma might affect transactions not only of contaminated sites themselves, but also of properties nearby. Contamination events can be “thought of as analogous to a stone dropped in a pond” (Slovic 1987, p. 283) with effects expanding beyond the initial direct harm. Greater consequences—perhaps described as more expansive stigma—appear systematically related to the same risk characteristics as above (Slovic 1987). In addition, because most potential purchasers view property as an investment, stigma may have exaggerated price effects. Purchasers are cognizant not only of the effects of potential contamination on themselves but also of the increased difficulty of selling the property in the future (Kunreuther and Slovic 2001).

While there is extensive literature on contamination, reputation and housing prices, it is inconclusive. Some researchers have found that residents living near contaminated sites assessed risks as similar to technically measured risks, and that these risks were reflected in property prices (e.g., Gayer, Hamilton, and Viscusi 2000). Others have found the opposite, suggesting that impressions were informed from available heuristics and evidence such as odors and visual appearance. Messer et al. (2006) noted that, “Erecting chain-link fences, posting 24-hour guards, placing warning signs, and conducting on-site tests with workers wearing protective clothing are all cues to residents that risk levels may be high” (p. 305). Proximity to a site increases the frequency and duration of these perceptual clues, contributing to risk beliefs. These findings are in line with the research on stigma and risk perception that suggests qualitative risk characteristics are perhaps just as important as quantitative risk measures in forming public perception (Slovic 1987).

Depending on the specific scenario, official identification of a site as contaminated and inclusion of it in a cleanup program could diminish stigma and facilitate a better functioning property market, or it might exacerbate stigma. If a community was already aware of a contaminated property, officially including it in a cleanup program should assure the public that risks will be remediated, which should increase property transaction rates and property values. On the other hand, if a community was unaware of a site or the severity of contamination until the determination that there is a need for cleanup, the process of identifying and labeling the site could unintentionally cause stigma. This might dampen the values and sales rates of nearby properties beyond what would be efficient according to a technical risk assessment. Empirical work provides limited evidence of these two opposite effects. Some studies have found price drops in contaminated or nearby properties following addition of the site to the NPL, while others have found no effect or price rebounds.[24]

Persistent stigma borne by sites that were accurately labeled as contaminated, but have undergone successful cleanup is a real concern (Messer et al. 2006); though the empirical evidence on the lasting impact of labeling a property as contaminated is mixed. Researchers have noted instances when residential and commercial property values have not recovered fully following completed cleanup efforts, implying a lasting stigma, though the opposite has held true elsewhere, particularly at industrial sites. Messer et al. (2006) highlighted media attention, cleanup delays, and other controversies as factors associated with persistent stigma following cleanup activities at high profile NPL sites.

[24] See Section 6.3.1.2.1 on property value studies and the timing of significant events surrounding contamination and cleanup.

In sum, stigma and poor information can lead to inefficient property markets for contaminated sites, potentially contaminated sites, and remediated sites. This inefficiency can extend to nearby properties. The information gathered and maintained through cleanup activities can improve property markets by providing reliable information and certifying remediation of affected areas.

4.1.3 Liability Rules and Property Markets

A different issue affecting the efficient operation of property markets is the effect on transactions and reuse rates of liability rules imposed by cleanup regulations. While liability rules may give incentives to firms to avoid contamination events in the first place, joint and several liability designating all past and current site owners as responsible parties may have discouraged transactions of properties suspected of past contamination, preventing properties from being directed at their highest valued use.

A Science Advisory Board panel noted the widespread perception that "the Superfund program actually created abandoned and underused properties because of fear of possible liability associated with the cost of cleaning up the site" (U.S. EPA 2006a, p. 30). Empirical studies have found joint and several liability laws to have led to higher vacancy rates among industrial sites located in city centers (Sigman 2006) and lower sales rates and lender financing for commercial properties adjacent to LUST sites (Simons, Bowen and Sementelli 1999). Of course, the effects of CERCLA liability rules have been tempered by the 2002 Brownfields Law. While CERCLA imposes liability on all potentially responsible parties, the Brownfields Law provides relief from liability for certain property owners (*bona fide* prospective purchasers, innocent landowners, and contiguous property owners) to facilitate reuse.

4.2 Spatial and Temporal Issues

Land contamination typically involves a persistent stock of toxic substances that can also give rise to slow-moving flows. Contamination of land is typically a result of activities that occurred in the past, and since dangerous pollutants can leach from contaminated soils for years, it can remain a long-term problem if not addressed. Reducing or eliminating the origin of land contamination, while important to prevent future damages, might not be sufficient to mitigate existing hazards, and cleanup efforts are often needed to diminish the accumulated stock of hazardous material. This situation contrasts with air and water pollution flows that can be reduced by putting controls on current polluting activities, such as installing scrubbers at coal-fired power plants.

Cleaning up persistent stocks of contaminated soil and ground water often involves upfront expenditures on costly equipment. Such sunk costs are unrelated to current production decisions, unlike variable costs that firms often incur when complying with air and water regulations (though fixed costs could be relevant to air and water cleanup as well). High sunk costs imply that the choice of technology and the comprehensiveness of the cleanup effort are irreversible in practice because such decisions are rarely revisited by regulators once they are made. Section 7.2.5 discusses the issue of fixed versus variable costs and its relevance for cost estimation.

The persistence of land contamination absent complete remediation can raise other unique cost issues, such as the need to supplement engineering solutions with long-term institutional controls to avoid inappropriate use of contaminated sites. In the notorious case of Love Canal, the Hooker Chemical Company noted the site's contamination in its deed of sale. However, this warning was disregarded when a school and residential housing were built on the site (Hourcle and Guenther

1999). This example suggests that institutional controls over contaminated properties, also called long-term stewardship, are essential when contaminants can persist over a longer time frame than the public's memory. Long-term stewardship, often under the purview of local or state governments, might include recordkeeping, monitoring of nearby ground and surface waters, and covenants restricting future uses of a property. Ongoing institutional controls are a unique cost of land cleanup and reuse that are discussed in Section 7.2.1.

While some costs are incurred upfront, the benefits of land cleanup can accrue far into the future or even indefinitely—for as long as the site would have inflicted damage in absence of the cleanup. Assessment of inter-generational benefits features prominently in land cleanup, though it is not unique to land cleanup per se. Chapter 6 of EPA's *EA Guidelines* (U.S. EPA 2010e) discusses discounting under both inter- and intra-generational scenarios. The valuation of such benefits has not been fully resolved in the literature.[25]

The benefits of land cleanup can be highly localized, such as increased productivity gains that accrue on-site or geographically dispersed, as in the case of averted ground water contamination. Off-site effects of land cleanup and reuse activities can be reflected in the prices of properties near contaminated sites. Property values might register the effects of a cleanup effort at different points before, during or after cleanup, or even after reuse, depending on the site-specific context. This challenge is discussed further in Section 6.3.1.2.1.

4.3 Variability across Sites, Contaminants, and Media

The nature and extent of land contamination can vary greatly from site to site. The size of affected sites can be small, as is typical for the UST program, or large, like some Superfund NPL sites. Nearby populations can be dense or sparse. Hazardous contaminants include arsenic, benzene, lead, mercury, perchlorate and trichloroethylene, to name a few. They pose risks of cancer and non-cancer health effects including birth defects, or present dangers such as fire or explosion. Contaminants appear in different combinations and concentrations. The exposure routes through which humans or wildlife might be affected include dermal contact, ingestion and inhalation. Although in most cases there is a fixed source of pollution, contaminants can be mobile and can reside in soil, ground water, surface water or air.

This heterogeneity across sites, along with the need to consider all potential future migration paths of the pollutants in question and the lack of a uniform national standard for land cleanup, means that the question of "how clean is clean" must be addressed on a site-by-site basis. Planned future site use is one factor that helps determine the stringency and permanence of cleanup efforts (Gupta, Van Houtven, and Cropper 1996). In addition, at many sites the cross-media effects and multiple contaminants make assessing cleanup benefits difficult because risk assessments have typically focused on individual contaminants. A Science Advisory Board panel on ecological risk assessment called for EPA to develop risk assessments for multiple contaminants and move beyond a pollutant-by-pollutant approach (U.S. EPA 2007b).

[25] For intra-generational analyses, EPA and OMB recommend three percent and seven percent discount rates, respectively. EPA also suggests considering benefits and costs without discounting or summing over time when examining an inter-generational context (U.S. EPA 2010e). In addition, it might be useful to employ the range of different discount rates suggested by EPA and OMB as a sensitivity analysis.

4.4 Land Productivity and Reuse Benefits

Estimating the full benefits of land cleanup involves going beyond the effects of removing or remediating contaminants to examine what happens once properties are deemed “ready for anticipated use.” Increased land productivity and site reuse can contribute substantial social benefits by increasing the production of goods and services that people value. This situation is particularly relevant when vacant or abandoned sites are remediated, effectively increasing the supply of usable land.

Increased production of valued goods and services that results from an increased supply of land is a benefit specific to land cleanup activities. This benefit is one target of the federal Brownfields Program, which has a legal mandate to facilitate site reuse in addition to cleanup. EPA’s Land Revitalization Initiative and other program-specific efforts such as the RCRA Brownfields Initiative also target land reuse. Both the benefits and costs of redevelopment made possible by land cleanup should be considered when examining the social welfare implications of cleanup and reuse activities. The distribution of benefits and costs across different groups could be affected by the type of redevelopment, such as industrial or residential, as discussed in Section 8.2.

In urban contexts, redevelopment can boost output at the community level through economies of agglomeration or can improve community welfare through peer group effects, in which neighbors influence each others’ behavior. Redevelopment of urban contaminated sites based on Smart Growth principles can lead to improved amenities for local communities and reduced pressure to develop open spaces or “greenfields” far from city centers, leading to indirect ecological benefits. These less conventional benefits are discussed further in Section 6.1.5.

4.5 Summary

The issues raised here pose unique challenges for analysts charged with assessing the economic effects of land cleanup and reuse. Compounded by the lack of existing comprehensive data, they are a source of ongoing debate among experts on the best approaches for estimating costs, benefits and impacts.

Some of these issues also have important methodological implications. For instance, the spatial and temporal scales of the effects of land cleanup mean that micro-level data that vary over space and time are often needed for benefits assessment. The variability in the types and concentrations of contaminants and affected media make it difficult to conduct risk assessment to measure health and ecological outcomes resulting from cleanup of unique sites. Heterogeneity among sites raises problems for the use of benefit transfer because finding study cases comparable to the policy case is often challenging, if not impossible.

The remaining chapters of this *Handbook* will explore these subjects in greater detail and offer recommendations on the advantages and shortcomings of different approaches to address them.

5 Partial Equilibrium and General Equilibrium Analysis

Before turning to the specific categories of benefits and costs arising from land cleanup and reuse and the methods used to measure them, presented are different modeling frameworks for BCA that depend on the breadth of the effects considered. The simplest models of cleanup and reuse effects are limited to direct effects and do not consider resulting changes in markets. Partial equilibrium models go a step further and focus on one or a few markets reflecting a targeted subset of the effects of land cleanup, usually those expected to be most pronounced. General equilibrium models trace pervasive changes through all related markets in the economy. In the context of land, the related markets of interest might be property markets in different neighborhoods or geographical locations not directly affected by the cleanup, rather than different industries or sectors of the economy.

The type of analysis that is most appropriate to understand the effects of a land cleanup activity or policy depends on the degree to which related markets are expected to change. In practice, available models and resources will also determine the chosen approach.

5.1 Defining the Extent of the Analysis

The most basic type of analysis of benefits or costs considers the impacts on households and firms directly affected by an environmental policy without considering changes in prices or consumer behavior. In the case of land cleanup, benefit estimates might focus on the reduced health risks experienced by residents in the immediate vicinity of a site, as measured by a risk-assessment based approach (further discussed in Section 6.2), making the assumption that residents do not relocate in response to the policy. On the cost side, analysts might consider the expenditures on labor and materials borne by responsible parties and the government without examining whether those costs trickle through entire industries and affect the prices paid and quantity demanded by consumers for goods and services.

Focusing on direct effects and holding prices and other market conditions constant may be a less reasonable representation of reality when analysts are charged with examining land and reuse policies with large or pervasive effects on the economy. More sophisticated partial equilibrium analyses of the benefits and costs of environmental policies extend the scope of the study to encompass changes in one or more affected markets; for example, examining the change in prices for properties near a cleanup site.

Examples that might call for even more extensive analysis include a cleanup activity large enough to cause concern about gentrification of a neighborhood through a potential changeover of residents, or a retrospective analysis of an entire cleanup program that spurred cleanup at hundreds or thousands of sites throughout the country and required multiple firms in many industries to finance cleanups, with expenditures high enough to cause some firm shutdowns. For these cases, a more comprehensive general equilibrium analysis might be required.

It is worth emphasizing that any data gathered to examine land contamination and cleanup will reflect the true general equilibrium processes that occur in the economy, regardless of the model selected to analyze the data. Thus, a key issue in defining the extent of the analysis is whether a simpler model that focuses on either direct or partial equilibrium effects provides a sufficiently close representation of reality to use as the analytical approach, given that opportunities for a more complete general equilibrium analysis could be limited by modeling, budget or time constraints.

5.2 PARTIAL AND GENERAL EQUILIBRIUM ANALYSIS

Partial and general equilibrium analyses consider to varying degrees the changes in economic conditions that occur in response to a policy and provide more complete estimates of benefits and costs by accounting for these changes relative to direct benefit or cost estimates. Partial equilibrium models focus on changes in a single or limited number of markets. They estimate changes in prices and quantities in the relevant market(s) to determine the new equilibrium likely to result from the policy. They use estimates of supply and demand elasticities to account for resulting consumer and producer behavioral changes. If market changes have occurred, these models provide a more complete picture of social costs or benefits than direct estimates alone. Partial equilibrium models can be local, regional or economy-wide. Local or regional models are more applicable to cleanup activities at a specific site, while economy-wide models are relevant for assessing entire EPA cleanup programs.

When a policy has significant enough effects to change prices, important non-price attributes, and behavior in the larger economy, a general equilibrium analysis is warranted.[26] General equilibrium models are conceptually appealing because they are capable of capturing many of the market and some of the non-market feedback effects that can occur across different sectors of the economy. Market feedback effects occur when the market of interest is affected by changes in the prices of related goods, while non-market feedback effects include impacts caused by changes in externalities or public goods like air quality or open space.

An example of general equilibrium analysis applied to land cleanup might involve a regulation targeting USTs at gas stations, which could be examined not just for its effect on gasoline prices, but also for its effects on prices of all goods upstream (petroleum) and downstream (travel) from gasoline to estimate costs. An example on the benefits side that includes non-market feedback might be an analysis of housing prices in response to cleanup that accounts for resulting changes in neighborhood composition, school quality, and other neighborhood attributes that could shift over time in response to land contamination status and in turn affect property prices. A full general equilibrium model would examine market and non-market effects connected to the upstream and downstream changes. It could also account for any interactions of the new policy with pre-existing distortions in the economy, such as taxes (Goulder 2002), and assess how costs filter through the economy differently depending on how a cleanup is financed, whether by a government or private company.

Computable general equilibrium (CGE) models capture diffuse effects by simulating producer and consumer behavior in multiple interrelated markets. When an environmental policy raises costs in one sector or causes a decrease in aggregate supply because some firms in an industry shut down, the model calculates new equilibrium prices and quantities in related markets, accounting for substitutions and other responses made by producers and consumers. Likewise, any impacts on national output of an increase in the aggregate supply of land could also be captured by a CGE model. Analysts are referred to EPA's *EA Guidelines* (2010e), Section 8.4 "Models Used in Estimating the Costs of Environmental Regulation," for a detailed treatment of CGE models, input-output econometric models, and other appropriate approaches, depending on the details of the case at hand.

[26] For more discussion of the differences between partial and general equilibrium models for policy evaluation, see Just, Hueth, and Schmitz (2004), Kokoski and Smith (1987), and Mohring (1971).

General equilibrium models used in policy analysis typically focus on changes in the prices and quantities of goods in other markets and how they affect the primary market of interest. It is less common for them to consider non-market effects and heterogeneous goods with multiple attributes. For land markets, this approach is unsatisfying due to the importance of geography and non-price attributes associated with location. As a result, general equilibrium methods are better developed for estimating costs than benefits. However, recent models examining the benefits of environmental policies and other improvements in public goods have begun to incorporate certain non-price impacts relevant to property markets. For example, equilibrium sorting models extend traditional models of household location choice to account for changes in housing prices, public goods and residential moving decisions throughout a relevant real estate market (Smith 2007, Kuminoff et al. 2010).

For the time being, equilibrium sorting and other similar models remain at the frontier of economics, and applications to policy questions are sparse. In addition, equilibrium sorting models typically do not extend to price and behavioral changes in other markets beyond housing. There is currently no unified general equilibrium modeling framework for estimating both market and non-market costs and benefits that can be applied to land cleanup and reuse. Analyses of localized and firm-specific effects remain appropriate if the scale of effects from the policy is limited, while equilibrium sorting models and other approaches that incorporate certain behavioral and price changes could be worthwhile if widespread effects are expected.

Some cleanups will take decades, if not longer. To estimate the effects of cleanups that are projected to take a very long time, a dynamic framework might be required. If the land cleanup activity is expected to have economy-wide inter-temporal effects, dynamic CGE models are appropriate, as discussed in the *EA Guidelines*.

5.3 Partial and General Equilibrium Analysis of Land Markets

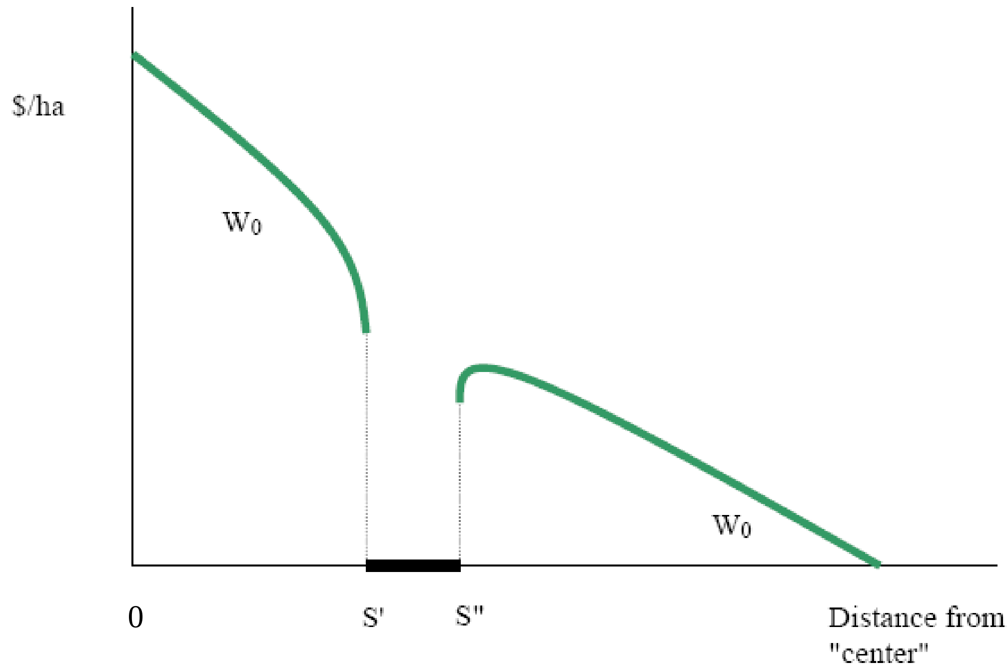
In the land cleanup and reuse context, hedonic property value models are a frequently encountered partial equilibrium analysis, discussed in detail in Section 6.3.1.1. Such analyses typically focus on the neighborhood near a contaminated site as the market of interest and examine the price changes in response to a land cleanup activity. A broader general equilibrium analysis would consider adjustments in housing prices and residents' locations not just in the localized housing market but across all neighborhoods in a metropolitan area or beyond using an equilibrium sorting model.

The economics literature uses the terms "partial equilibrium" and "general equilibrium" analyses somewhat differently when applied to markets for land and community attributes (e.g., Smith et al. 2004, Sieg et al. 2004, Walsh 2007) as compared to their usage in cost estimation. On the cost side, general equilibrium models typically trace price changes in all industries throughout an economy in response to an environmental policy (e.g., Hazilla and Kopp 1990). The analogous situation when estimating the benefits of land cleanup capitalized in property markets is to consider changes in all property markets and associated non-market attributes like crime rates or school quality that could be affected directly or indirectly by cleanup. This type of analysis reflects the fact that land raises more complex issues than many other commodities because it is heterogeneous, with geographical features and other attributes that vary across space.

Presented below is a brief theoretical discussion of the impact of site cleanup on property values—informed by the urban economics literature—to highlight the differences between partial and general equilibrium analyses of land cleanup policies. Readers less interested in this theoretical background may skip this section without losing continuity.

To illustrate the benefits of reducing land contamination, a stylized urban setting is considered. Using an urban economics model of land markets, Figure 5.1 depicts willingness to pay (WTP) for land before cleanup in a geographically contained urban area, measured in dollars per hectare on the y-axis. Land is represented as a heterogeneous good with distance from the city center defined as the key attribute of interest. Initial WTP for land parcels, represented by the curve W_0, is assumed to decline with distance from the center (shown on the x-axis). Figure 5.1 depicts an extreme case in which, prior to cleanup, the value of a contaminated land parcel (indicated by the segment between S' and S") is zero, with spillover effects dampening the value of nearby properties. (A less severe case of contamination might result in WTP for the parcel that is low relative to neighboring properties but still greater than zero.)

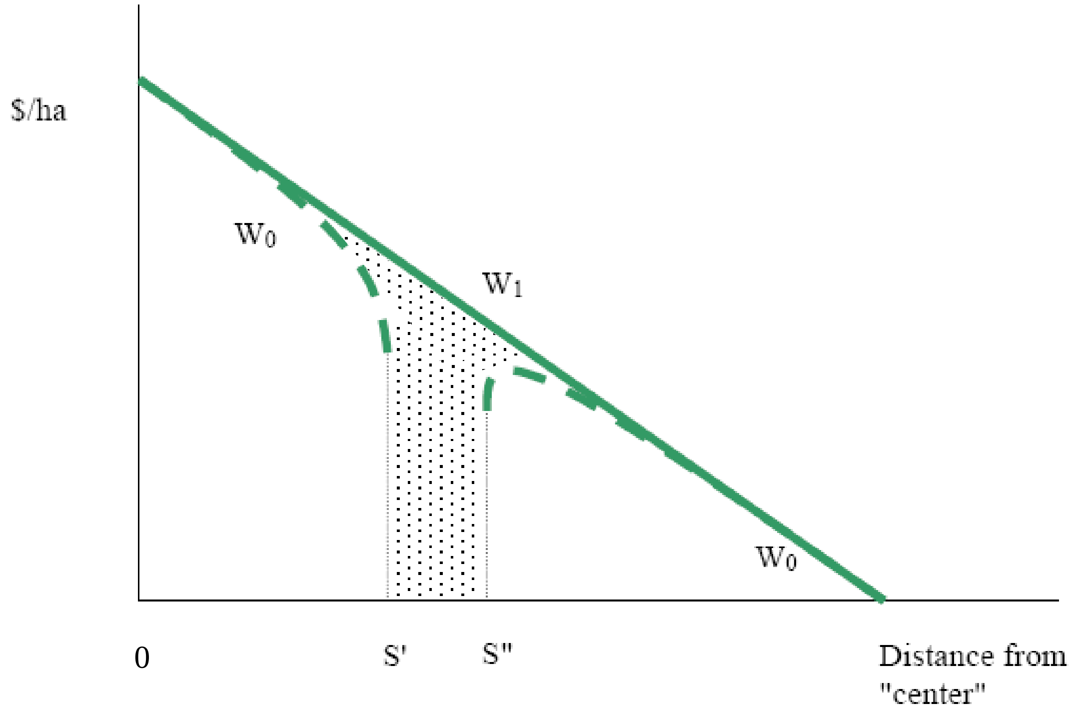
Figure 5.1 - Willingness to Pay for Urban Land Before Site Cleanup



Reproduced from Jenkins et al. (2006)

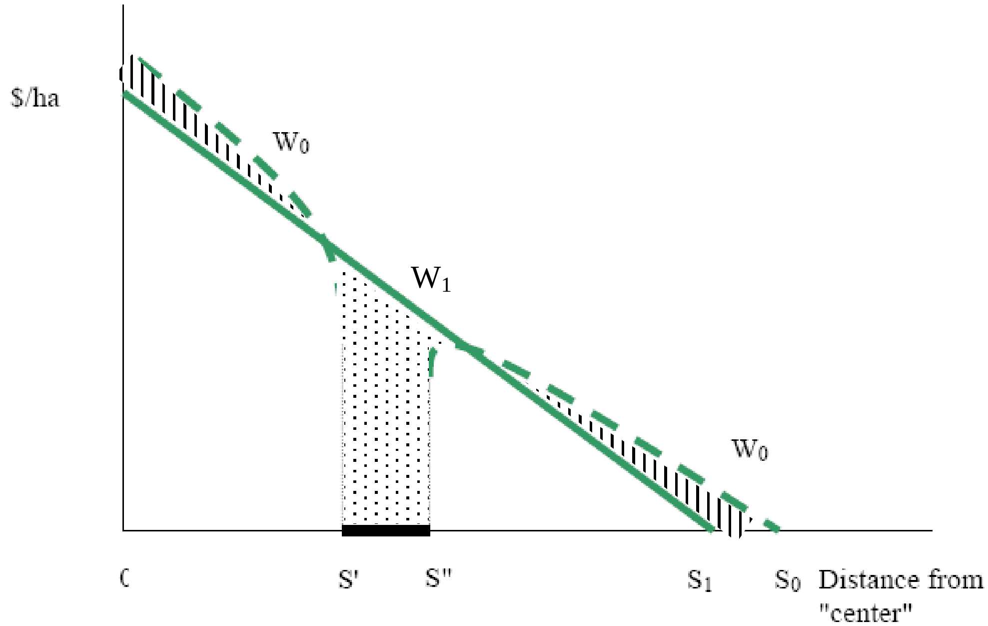
Figure 5.2 represents the urban land market after cleanup. Remediating the contaminated site restores the WTP curve to W_1, boosting the value of the site and of adjacent properties. Whereas prior to cleanup, the contaminated site had no market value despite its relative proximity to the city center, after cleanup distance from the center becomes the key determinant of WTP for the parcel. Comparing the difference in the area under the two WTP curves indicates the value of increasing the supply of developable urban property. The dotted area in the figure represents the social benefits of land cleanup (such as lower health risks and improved aesthetics) that are reflected in property values at and near the site. The figures thus far reflect a partial equilibrium analysis of land prices, based on an assumption of constant land price patterns.

Figure 5.2 - Willingness to Pay for Urban Land After Site Cleanup: Partial Equilibrium Analysis



The preceding partial equilibrium analysis applies if the contaminated property is small enough relative to the supply of local land that its cleanup does not significantly affect the rest of the real estate market. However, a general equilibrium analysis might be warranted if the site is large enough that adding it to the market affects property prices throughout the urban area. In this situation, a sufficient increase in the quantity of developable land can reduce WTP for any particular parcel because the total supply of land is higher. This effect is represented in Figure 5.3 by the leftward shift in W_1. In the extreme case, this effect could cause the boundary of the city to contract from S_0 to S_1, though population and economic growth over time make this scenario less likely.

Figure 5.3 - Willingness to Pay for Urban Land After Site Cleanup: General Equilibrium Analysis



The general equilibrium benefits measure, represented by the dotted area in Figure 5.3, is smaller than the partial equilibrium benefits measure in Figure 5.2 because of this decrease in land values throughout the market. Of course, this benefits measure is still positive even if equilibrium property prices throughout the urban land market fall relative to the baseline scenario. The fall in prices at properties not directly affected by the cleanup, represented by the two dashed areas in Figure 5.3, leads to a transfer of resources away from current property owners. Some of the transfer would go to current renters and the remainder to future buyers. The dashed areas represent a pecuniary effect rather than a social benefit or cost of the land cleanup program.

This example illustrates a more general result that estimates based on property values that do not account for general equilibrium adjustments can overestimate the benefits of land cleanup and reuse. The size of the discrepancy between the two estimates depends on the quantity and importance of the remediated land compared to the size of the property market as a whole. Cleanup programs that target very large sites or many parcels throughout a real estate market are more likely to have far-reaching effects on prices than programs targeting smaller or fewer sites. Equilibrium effects are also more likely if residents cannot easily move between cities, or if cleanups occur in multiple cities simultaneously, both of which raise the total quantity of remediated land relative to the area over which people make decisions about where to live. (Brueckner's peer review comments on the draft *Handbook* found in Smith 2011 offer a stylized derivation of this relationship.)

Changes in prices throughout a real estate market make it more likely that residents decide to move as a result of the cleanup. For instance, an improved appearance and lower health risks that are capitalized into higher housing prices near a cleaned up site could spur some renters to move away in search of cheaper housing, while other residents who previously avoided the neighborhood due to the contamination move closer. Such spatial sorting can complicate the empirical analysis of land cleanup benefits using property values, as will be discussed further in Section 6.3.1.2. Evidence has been found of residential sorting in response to improved air quality, which can have important regional effects on housing prices and demographic patterns (Sieg et al. 2004, Tra 2010). Equilibrium sorting models account for these response patterns and examine related changes, such as other housing attributes. An even more comprehensive analysis would also account for changes in other markets affected by cleanup programs besides land, such as markets for labor or construction materials.

It is possible that widespread price changes in land markets could lead to additional welfare effects by interacting with other unpriced externalities. In particular, reducing development on the urban fringe because land becomes more available and competitively priced in the city center can lead to ecological benefits by preserving open space. The benefits of preserving greenfield areas are discussed further in Section 6.1.5.4. Having businesses move into redeveloped parcels in urban areas could also improve the productivity of nearby firms through agglomeration effects, which is discussed in Section 6.1.5.2. These are both general equilibrium effects because they depend on changes in the wider economy that would be overlooked by an analysis focused only on regulated firms or on the property market in the neighborhood of the site. When general equilibrium effects lead to these types of positive externalities, simple benefit estimates that hold land prices constant could understate true benefits.

5.4 Summary

Direct estimates of land cleanup benefits and costs focus on the regulated firms and the nearby residents likely to be most affected by a policy or program. Partial equilibrium analysis focuses on effects that permeate a market, while general equilibrium analysis examines feedback effects or changes throughout the wider economy. Even though the outcomes that actually occur in the marketplace reflect general equilibrium processes, models that estimate direct effects or that examine a single property value marketplace without considering general equilibrium price changes, currently offer the most tractable approaches for assessing land cleanup and reuse benefits and costs. These models have the potential to provide reasonable estimates for the effects spurred by individual site cleanups or from programs that affect smaller amounts of land. Many of the specific methods discussed in the following chapters do not consider general equilibrium effects.

Because existing empirical research suggests that land cleanup effects are quite localized, it is possible that effects on the larger economy are negligible in many cases, making general equilibrium measures less of a priority for policy analysis. The size of the discrepancy between direct, partial and general equilibrium measures of cleanup and reuse benefits and costs is a research question deserving more attention. Future models could provide analysts with more tools to examine this issue. In the meantime, analysts using more localized or partial equilibrium models to obtain quantitative estimates of land cleanup benefits and costs may want to consider qualitatively whether general equilibrium effects are likely. If so, describing them and discussing whether they are expected to increase or decrease net benefit estimates would be worthwhile.

6 Benefits Estimation

This chapter discusses the social benefit categories associated with land cleanup and reuse and the methods appropriate for estimating them. Despite recent efforts to assess EPA cleanup programs, conceptualizing and measuring their social benefits has proven difficult. Indeed, there has been no systematic accounting of the social benefits of any EPA cleanup or reuse program, despite two proposals to undertake such an analysis for the RCRA, UST, and Superfund programs (U.S. EPA 2006b, U.S. EPA 2000a, b).

This chapter synthesizes the results of recent papers, workshops and Science Advisory Board reports to provide up-to-date information to analysts undertaking benefits assessment. The first section explains the types of benefits expected to result from land cleanup and reuse activities. Attempted or proposed efforts to estimate land cleanup and reuse benefits have largely focused on health and amenity improvements. These categories are discussed, as well as other potential benefits that have received less attention until recently. The objective is to describe a set of benefits arising from land cleanup and reuse that is as complete as current information permits.

The second section of the chapter discusses risk assessment as a means to obtain information on the effects of site cleanup on human health and ecological endpoints. Risk assessment is not a valuation method; rather, it is a common approach to quantify the biophysical effects of environmental policies and programs. These biophysical effects can serve as important inputs to benefits valuation.

The third section explores the economic valuation approaches used to monetize the benefits of land cleanup and reuse activities. It focuses in particular on property value models and SP surveys but also considers other methods. It discusses how each approach applies in the land cleanup and reuse context and highlights some examples from the literature.[27] It explains issues to consider when assessing the quality of estimates, how analysts might improve upon certain estimation methods, and how to interpret empirical results from different models. The discussion of each method closes by summing up advantages, limitations and recommendations for analysts crafting benefits assessments. The chapter closes with a discussion about applying existing benefit estimates to specific policy scenarios using benefit transfer.

As an aside, *avoiding* land contamination through proper materials management generates many of the same types of benefits as land cleanup, such as reduced health risks, protected ecosystems, and improved site productivity. Although preventing contamination is not the subject of this *Handbook*, some of the valuation approaches discussed in this chapter could prove useful for analysts assessing the benefits of prevention programs. Additional methodological challenges remain for these analysts to estimate if, when and where contamination would have occurred in the absence of the program. These are uncertainties that are not encountered when dealing with land cleanup because the contamination has already happened, though an analysis of cleanup benefits would still require predicting where contamination might have migrated without the cleanup activities. The social costs and economic impacts of prevention programs are likely to be quite different from those of land cleanup, since prevention affects ongoing production practices and is not closely linked to reuse.

[27] Jenkins et al. (2006) provide a more complete literature review.

6.1 Benefit Categories

Contaminated land can taint nearby soil and ground water or spawn releases of toxic material through air- and waterborne channels. Idle properties can create neighborhood eyesores and sap opportunities for urban development. Cleanup activities mitigating these problems can increase well-being by improving human health and amenities, restoring ecosystems, and reversing materials damages.[28] In addition, reusing formerly contaminated land can enhance social well-being by improving land productivity, and if changes in property values are significant enough to affect the urban fringe, preserving greenfield space.

Table 6.1 summarizes these benefit categories, offers some examples, and presents methods commonly used to measure them. While the categories are intended to capture the complete set of land cleanup and reuse benefits, the list of examples is by no means exhaustive. Likewise, the included methods are not necessarily the only approaches for assessing each category of benefits; however, the list is provided to help refer the reader to relevant methodological discussions later in the chapter.[29] Because these methods measure overlapping concepts and benefit categories, it is generally not appropriate to sum the results of different approaches to yield an estimate of total WTP for land cleanup and reuse.

Table 6.1 also distinguishes between benefits stemming from site cleanup and those derived from site reuse, though they are not mutually exclusive. For instance, remediating hazardous wastes that contaminate surface water can lead to ecological benefits such as reduced contamination of fish populations and restored habitat, while reusing formerly contaminated sites by converting them to parks can help reduce surface water runoff and improve a neighborhood's visual appearance, generating ecological and amenity benefits. Further, the heterogeneity across sites and reuse options means that not every benefit category will be relevant for every cleanup and reuse project.

[28] The discussion of these "conventional" sources of benefit is kept brief to avoid redundancy with Section 7.3 of the *EA Guidelines* (U.S. EPA 2010e), "Economic value and types of benefits," which furnishes more background on these categories.

[29] It is worth noting that not all the methods listed in the table yield theoretically equivalent measures of WTP for land cleanup and reuse. For example, revealed preference studies estimate Marshallian welfare measures, while SP studies can estimate Hicksian or Marshallian welfare measures. Hedonic property value models measure marginal WTP, while SP surveys measure total WTP, and cost of illness only serves as a valid proxy for WTP in certain situations. Later in the chapter is an in-depth discussion of the most common valuation approaches used for measuring land cleanup and reuse benefits, and when relevant, the expected WTP concept. See the *EA Guidelines* Section 7.4 for a comprehensive discussion of the theoretical foundations of each valuation method.

Table 6.1 - Potential Benefits of Land Cleanup (c) and Reuse (r) Activities

Benefit Category	Examples	Commonly Used Valuation Methods
Human Health Improvements		
Mortality	Reduced risk of: ▪ Cancer fatality (c) ▪ Acute fatality (c)	♦ Averting behaviors ♦ Property value models ♦ Stated preference
Morbidity	Reduced risk of: ▪ Cancer (c) ▪ Accident & injury (c) ▪ Lead poisoning (c) ▪ Birth defects (c)	♦ Averting behaviors ♦ Cost of illness ♦ Property value models ♦ Stated preference
Ecological Improvements		
Market products	▪ Improved fish harvests (c)	♦ Production/cost function
Recreation activities and aesthetics	▪ Enhanced hiking, boating, fishing (c)(r) ▪ Scenic views (c)(r)	♦ Production/cost function ♦ Averting behaviors ♦ Property value models ♦ Recreation demand ♦ Stated preference
Valued ecosystem functions	▪ Reduced surface water runoff (r) ▪ Increased soil permeability (r)	♦ Stated preference ♦ Production/cost function ♦ Averting behaviors
Nonuse values	▪ Restored or preserved species or ecosystems (c)(r)	♦ Stated preference
Other Benefits		
Aesthetic improvements	▪ Improved neighborhood appearance (c)(r) ▪ Improved drinking water taste and odor (c)	♦ Averting behaviors ♦ Property value models ♦ Stated preference
Reduced materials damages	▪ Reduced corrosion and soiling (c)	♦ Averting behaviors ♦ Dual-profit function ♦ Production/cost function
Land productivity improvements	▪ Increased goods and services (c)(r) ▪ Increased labor productivity (c)(r)	♦ Production/cost function ♦ Property value models

Adapted from *EA Guidelines* (U.S. EPA 2010e).

6.1.1 Human Health Benefits

With respect to human health, the benefits of pollution reduction take many forms. Some of the most common are reduced mortality risk from illness and acute fatalities, and reduced morbidity risk from asthma, nausea, cancer, birth defects, adverse reproductive or developmental disorders, and other illnesses or injuries. Land cleanup can help avert health risks both on- and off-site – current and future employees might face lower health risks on-the-job following cleanup and nearby residents can experience health benefits as well.

Contaminated land can affect human health through multiple pathways and media—air, water and soil—and a wide variety of hazardous substances. Contaminants appear in different combinations and concentrations. As noted in Table 6.1, health benefits largely arise from cleanup rather than reuse of contaminated sites, though the possibility that more efficient land uses can foster improved health outcomes is not ruled out.

6.1.2 Ecological Benefits

While many contaminated sites are located in industrial areas, land cleanup programs can sometimes mitigate contamination that affects wildlife populations and ecosystem productivity. Reusing formerly contaminated properties can also result in ecological benefits, particularly when park or wilderness areas are established on the site. Strengthening ecosystems can generate positive externalities and make communities more livable.

Ecological benefits are improvements in ecosystems that contribute to human welfare. Several ecological benefit categories are relevant to land cleanup and reuse, as noted in Table 6.1. Ecosystems provide market goods such as food or fresh water, which can be improved by removing pollutants from drinking water supplies or fishery habitats. Cleanup of unattractive or hazardous sites can increase non-market goods such as recreational activities and aesthetic enjoyment. Site reuses that increase soil permeability and decrease runoff can enhance ecosystem functions such as hydrological regulation as well. For example, Superfund Remedial Program work at the Milltown Reservoir NPL site in Montana's Clark Fork River Basin involves not only remediation of contaminated sediments caused by mining, but also removal of a dam, restoration of the natural river channel and floodplain, and creation of a state park (U.S. EPA 2010d).

In addition to direct and indirect use values, ecological benefits also include the nonuse value people derive from the knowledge that land in their community or country is less contaminated or that wildlife populations face lower risk, even if the people themselves are not tangibly affected.[30] Nonuse benefits from land cleanup and reuse seem secondary in importance relative to health and aesthetic benefits, but they might be relevant for sites with particular historical or cultural value, or they could reflect a more general preference that land should not be contaminated. Defining and estimating the magnitude of potential nonuse benefits from land cleanup and reuse projects remains an area for future research.

6.1.3 Aesthetic Improvements

Aesthetic improvements are benefits people derive from consuming environmental goods with improved taste, odor or visibility. Cleanup can address contaminated properties that are unsightly or give rise to air- and waterborne pollutants causing off-putting smells and distasteful drinking water. Reuse activities can also improve site appearance.

6.1.4 Avoided Materials Damage

Contaminants lingering in the soil or leaching into ground water have the potential to damage buildings, equipment and infrastructure. Materials benefits are the reductions in such damages to manmade structures or systems. While some studies have examined materials benefits in housing from air pollution reductions, estimates from land cleanup activities are rare. However, such

[30] These categories correspond roughly to the types of ecosystem services outlined by the Millennium Ecosystem Assessment (2005), though they are named differently here in accordance with the *EA Guidelines*.

benefits could be important if land contaminants cause damage to physical structures either on-site or on nearby properties.[31]

6.1.5 Increased Land Productivity

Increased land productivity resulting from cleanup activities is a different source of benefits than those described above—one that is not addressed in EPA's *EA Guidelines* (2010e). Because a property's value is determined by the expected flow of profits it can generate over time, cleaning the parcel can increase its value by enhancing the productivity of ongoing activities or allowing the production of more valuable goods and services.[32] In addition, land cleanup efforts that target abandoned or vacant properties increase the quantity of developable land that can then be put to its highest valued use.

Following cleanup with redevelopment often entails bringing a property into a use that has a higher value than its prior incarnation. For instance, under the Brownfields Program, former junkyards, parking lots and vacant properties have been converted to waterfront parks, high-rise hotels and residential developments. The net benefits of site cleanup and reuse can be calculated as the difference between the value of the property before and after cleanup and redevelopment, less remediation and redevelopment costs.

Cleanup and reuse can increase land productivity directly and indirectly. Improved information can lead to a higher rate of property transactions and redevelopment. Land cleanup and reuse might also increase opportunities for agglomeration effects in urban areas. Improving physical structures and employment opportunities might spur positive peer-group effects that reduce crime or other undesirable activities. In addition, the possibility discussed in Section 5.3 that redevelopment of remediated sites could allow an urban area to contract (or not expand when it otherwise would have) suggests that land cleanup and reuse might promote the preservation of greenspace at the urban boundary. The following four subsections examine these issues in greater detail.

6.1.5.1 Improved Information and Increased Property Transactions

Improved land productivity can result from improved information about a parcel's contamination status that is revealed through a cleanup program, even if remediation is not necessary. As already discussed in Chapter 4, both actual and *potential* liability can prevent transactions when the true extent of contamination is unknown, as is often the case. Imperfect information and related uncertainty about the extent of contamination can lead property markets to function inefficiently, reducing the number of sales and ultimately the number of sites in productive use. Evidence suggests that developers and potential buyers are often reluctant to take on potentially contaminated properties due to liability concerns (Lange and MacNeil 2004a, b; Alberini et al. 2005; Wernstedt et al. 2006a, b). A lower rate of property transactions can lead to welfare losses by delaying or preventing land from being used by the most productive owner or devoted to its

[31] For a review of international literature concerned with the risks from contaminated land to buildings, building materials and services see Garvin et al. (2000). Also see Tedd et al. (2001) for a discussion of the durability of construction materials in contaminated ground.

[32] When reuse is made possible by risk reductions that stem from cleanup, there could be overlap between land productivity benefits and human health, amenity, ecological and materials benefits. While conceptually distinct, these benefits could be difficult to separate in practice.

"highest and best use." Land cleanup and reuse can remove uncertainties or other factors inhibiting property sales, fostering socially optimal use.

Imperfect information can deter property sales for various reasons. "Mothballing" hinders transactions when landowners avoid selling marketable properties for fear that costly cleanup issues will arise during redevelopment. Anecdotal evidence collected by Greenberg, Downton, and Mayer (2003) has suggested that mothballing is most likely to occur in smaller cities where developable land is only somewhat scarce and property values moderate, but local financial resources are not sufficient to cover cleanup costs. The authors asserted that mothballing was less prone to afflict properties in high value urban areas, where development potential exceeds the risk of high cleanup costs. In addition, many local officials considered contaminated properties in outlying low value areas to be justifiably left off the market because use values would likely remain low even after redevelopment (Greenberg, Downton, and Mayer 2003). In other words, mothballing only leads to welfare losses if the social benefits of cleaning up the site outweigh the social costs.

Asymmetrical information about contamination could also discourage buyers by creating a "market for lemons," as described by Akerlof (1970).[33] In this case, properties with high levels of contamination are more likely to change hands since sellers are willing to accept low prices, while less-contaminated, higher priced sites languish without redevelopment due to buyers' suspicions, despite the greater potential for efficient reuse of the higher priced sites (Zabel 2007, Boyd et al. 1996).

The concern regarding imperfect or asymmetrical information is that welfare gains that would result from a transaction between a buyer that values the property more than the seller are not realized. Increased property transactions are not a category of social benefits themselves (and thus do not appear in Table 6.1), but they might be associated with an increase in land productivity that arises from improved information. Empirical evidence on the impact of imperfect contamination information on sales rates and land productivity remains limited and remains an area for further research.

6.1.5.2 Agglomeration

Reuse of urban brownfield sites can also contribute to improved productivity on surrounding properties through economies of agglomeration, which are benefits to firms arising from geographic concentration near one another. Explanations proffered for agglomeration include shared inputs such as infrastructure, availability of a specialized labor force, lower transportation costs, better market access, and information sharing. Rosenthal and Strange (2004) have highlighted evidence suggesting that natural advantage, home market effects, consumption opportunities, and rent-seeking may also motivate self-perpetuating urban growth and concentration. Some of these factors, such as shared infrastructure, could spur agglomeration of residential developments as an alternative or in addition to commercial and industrial agglomeration.

[33] Asymmetry occurs in many contexts related to contaminated land: for instance, when the seller possesses more accurate information about the level of contamination than the buyer, or when the buyer has more information than the lender.

Redevelopment of urban space adjacent to other firms can help generate these types of positive spillovers, contributing to increased WTP for land in the vicinity of remediated properties. Greenstone, Hornbeck, and Moretti (2010) found evidence for agglomeration using a quasi-experimental study design by estimating that existing plant productivity improved after new "million dollar plants" opened in the same county. Empirical evidence is inconclusive about whether these benefits accrue only within an industry or across industries within a localized area. In practice, these benefits seem likely to be difficult to estimate for policy analysis. More information would be required on differences in marginal agglomeration effects across industries and metropolitan areas in order to estimate the impacts of a particular cleanup and reuse project.

6.1.5.3 Peer-group Effects

Revitalizing contaminated land might displace illegal or undesirable activities such as drug use and crime that sometimes become established in abandoned or underutilized areas. These positive effects could result from new uses of formerly contaminated land, or from revitalization efforts that create new jobs for the structurally unemployed. Additional reductions in crime or other undesirable behavior might then result from peer-group effects, in which people influence their neighbors' behavior through social pressure or role modeling. Peer-group or neighborhood effects have been demonstrated in the areas of crime, drug and alcohol use, employment and education (Durlauf 2004). If redevelopment of a formerly contaminated site helps displace illegal activities, further reductions in those activities from peer-group effects could lead to higher land productivity. Unlike agglomeration, this effect does not necessarily result from high development density, even though it can occur in an urban setting. Like agglomeration, this effect is likely to be difficult to measure.

6.1.5.4 Greenfield Preservation

As discussed in Section 5.3, if remediated urban spaces are large or significant enough to change local development patterns, they might relieve pressure on undeveloped land on the edges of the city. Such "greenfields" can include open space or agricultural land. Preserving greenfields can lead to social benefits if they provide ecological services or amenities such as bucolic views, biodiversity habitat, nutrient cycling, biological carbon sequestration, or recreational opportunities. If denser development leads to reduced driving, less greenfield development, or less infrastructure, it can decrease air pollutants or greenhouse gas emissions as well (U.S. EPA 2009b).[34] These benefits arise indirectly as a result of reclaiming land in urban settings, in contrast to the direct improvement in ecological services from land cleanup and reuse discussed in Section 6.1.2. Table 6.1 does not list greenfield preservation explicitly because it is not a separate benefit category, but rather a source of benefit categories that already appear, including ecological and aesthetic benefits.

The damages averted by urban reuse activities depend on the amount of greenfield space that would have otherwise been developed, termed the "brownfield/greenfield offset" by Deason et al. (2001). Baseline development patterns are likely to depend on overall real estate market

[34] An OSWER report discusses opportunities for reducing greenhouse gases through land revitalization (U.S. EPA 2009b). If significant CO_2 emission reductions or sequestration are expected to result from development patterns attributed to urban reuse, these benefits can be monetized for use in BCA. An Interagency Working Group (2010) Technical Support Document provides guidance on the monetized benefits from reducing a ton of carbon dioxide emissions, also known as the "social cost of carbon."

conditions. The damages averted also depend on the specific ecosystem services provided by the undeveloped greenfield area. Some studies have argued that each unit of reused urban land preserves as much or more open space because of low density development regulations and low land prices typical in many suburban areas. Five studies conducted by the Office of Brownfields and Land Revitalization and Office of Sustainable Communities examined different land use and transportation patterns associated with redeveloped brownfield properties relative to hypothetical greenfield developments. The comparisons suggested that brownfield reuse led to lower vehicle miles traveled and hence a reduction in air pollution emissions, including greenhouse gases. The site comparisons also suggested that redeveloped brownfields reduced storm water runoff relative to the hypothetical greenfield developments. The studies suggested a range of impacts due to regional variation in development and travel patterns (U.S. EPA 2011b).

In addition to ecosystem preservation, there may be reduced use of resources from reusing public infrastructure already existing at urban brownfields, as opposed to building new infrastructure as might be required for greenfields. For example, urban sites may already be serviced by power, sewer and transportation infrastructure that would otherwise need to be provided to greenfields. Several studies have estimated the cost and benefits associated with urban brownfield redevelopment and have suggested that the cost savings from avoiding the construction and maintenance of new infrastructure might be significant (De Sousa 2002, Persky and Wiewel 1996).

Infrastructure cost savings are a challenge to estimate and are likely to vary so much that generalizing beyond a single case is difficult. One cause of the difficulty is the need for a baseline reference. In order to quantify the savings associated with increased use of existing transportation and services infrastructure, one must understand the infrastructure expenditures that would have been required were the development to have occurred at a hypothetical greenfield location. Furthermore, one must understand the current state of existing infrastructure at the urban site being remediated, and what will be required to accommodate the intended reuse. This suggests that public infrastructure cost savings that result from cleanup and reuse projects will be unique to a project and a challenge to generalize.

Estimating ecosystem service benefits and offset ratios also requires some knowledge about the greenfield land likely to have been developed in the absence of the reuse activity. Identifying open space sites that were not developed but plausibly might have been is a major challenge of assessing the greenfield-related benefits of land reuse, particularly since the dynamics of urban expansion into fringe areas are complex and differ from city to city and year to year. It is also important to recognize that any calculation of greenfield-saving benefits assumes that open space would have been converted if the contaminated site were not reclaimed. If another urban site would have been redeveloped instead in the absence of the cleanup and reuse activity, green space preservation does not constitute a social benefit of the program.

6.2 Risk Assessment: A Potential Input to Benefits Valuation

As outlined in Chapter 7 of the *EA Guidelines*, sometimes an important step between defining the relevant benefit categories and measuring their value is determining the biophysical effects that give rise to these benefits. Risk assessment is a common approach to establishing the effects of a policy, program or activity on human health and ecological outcomes.[35]

Risk assessment is not a valuation method. It can, however, provide important input to benefits valuation by quantifying the biophysical effects of environmental policies and programs. Applying risk assessment to land cleanup and reuse programs involves identifying toxins and pathways, the associated health and ecological risks, and the size of affected populations (Smith 2007). This approach becomes more complicated as more toxins, exposure pathways and health or ecological outcomes are involved—each presenting an additional effect to be estimated, and the combination raising potential concerns about cumulative effects. It involves the work of risk specialists, epidemiologists, toxicologists and other experts outside of economics to quantify the exposure and risk reductions attributable to a cleanup effort.

The risk assessment approach is attractive in theory because it models the physical process by which cleanup actions lead to improvements in specific health and ecological outcomes. Risk assessment is particularly useful for highlighting the level and type of health risks posed by a contaminated site. It allows for prospective analysis of cleanups. If the reduction in contamination caused by cleanup activities can be predicted with reasonable accuracy, then potential benefits could be calculated in advance. Or, following similar analytical steps, reduced contamination caused by preventative measures or “avoided costs of contamination” could be valued if analysts can also estimate the probability that a contamination event would have otherwise occurred.

Translating information from a risk assessment into a measure of benefits requires estimating the value of the reduced risk. The responsibility for this final monetization step lies with economists. Ideally, the estimate represents the affected populations’ WTP for lower risk. Such estimates are obtained from both revealed and SP studies. However, WTP estimates for reduced risks are unavailable for many health outcomes, particularly for non-cancer illnesses. When WTP values are unavailable, a less desirable option is for the estimate to represent the costs of experiencing illnesses that are avoided by the reduction in risk (an approach discussed further in Section 6.3.3.1).

Given the wide variety of potential contaminants and cross-media effects at many contaminated sites, the task of valuing risk reduction from cleanup can be daunting. Still, the approach can be made more tractable with some simplifying assumptions, especially for a set of similar sites contaminated by the same pollutants or industrial processes. Analysts may focus on only one hazardous substance identified by a risk assessment and perhaps even on just one of that substance’s exposure pathways.

[35] Risk assessment might also be relevant for aesthetic benefits like taste and odor improvements, though it is more commonly used to assess health and ecological effects.

For example, to assess the benefits of regulating disposal of coal combustion residue (CCR), a recent regulatory impact analysis (RIA) examined only the health effects associated with ground water contaminated with arsenic even though additional constituents and pathways also posed health risks. An EPA risk assessment measured peak risks associated with arsenic and other hazardous substances, depending on the type of waste management unit and liner, as well as the age of the affected population. To carry out benefits analysis, the locations of existing disposal units and their liner types were identified. Private ground water wells within a mile of the waste units, and the numbers and ages of people drinking from them were identified as potentially affected. The RIA linearly extrapolated peak cancer risks to annual cancer risks and estimated the number of avoided cancers from ground water contaminated with arsenic. Before monetizing the number of cancers avoided, analysts divided cases into fatal and non-fatal, bladder and lung. Benefits were then monetized applying the value of a statistical life estimate published in the *EA Guidelines* and cost of illness (COI) estimates. The analysis was careful to highlight that the monetized benefits neglected health effects from other pathways and contaminants (U.S. EPA 2009a, U.S. EPA 2010c).

This example suggests that risk assessments can be relevant for assessing land cleanup programs. To improve the usefulness of the risk assessment, choosing the most threatening contaminant and pathway, and settling for COI rather than WTP estimates, especially for noncancerous effects, can dramatically improve practicality of valuing risk reductions from land cleanup.

Box 6.1 - Assessing Superfund Health Benefits Using Risk Assessment: Two Case Studies

Some studies have used the risk assessment approach as part of a strategy to estimate the value of health risk reductions from remedial actions at Superfund sites. Hamilton and Viscusi (1999) examined the cost-effectiveness of the Superfund program in terms of avoided cancer risks. (They did not examine non-cancer health risks.) The authors articulated the complexity of calculating risks for land cleanup, asserting that:

"A given risk pathway at a site is defined by a number of assumptions, including time scenario of exposure (for example, does the pathway involve a current or future land use?), exposed population (residents or workers?), exposed age group (adult or child?), population location (on-site or off-site?), exposure medium (soil or ground water?), medium location (on-site or off-site?), and exposure route (dermal or ingestion?)." (p. 6)

To address these issues, they compiled a database covering over 20,000 chemical exposure pathways and determined individual risks from soil and ground water contamination. Originally targeting 267 Superfund sites nationwide where RODs were signed in 1991-92, they narrowed the sample to 150 sites based on the availability of risk assessments. They then calculated population cancer risks by combining individual risk measures with geographic data on the number of people living within the vicinity of each site. They found the sites to differ vastly in the number of cancer cases averted by remediation, ranging from less than 0.1 to 652 over a 30-year period. Indeed, one site accounted for close to 90 percent of all averted cancer cases estimated among the sample.

Lybarger et al. (1998) focused on Superfund sites listed on the National Exposure Registry with volatile organic compound (VOC) contamination and potential for human exposure. They examined the risk of birth defects, diabetes, anemia and several other health conditions caused by VOCs in drinking water, a potential exposure pathway for land contaminants. They used the cost of illness approach to estimate the value of adverse health outcomes occurring within half a mile of these 258 sites, and found that total expected damages were approximately $330 million per year. The authors did not estimate site-specific damages, so the study does not shed light on the heterogeneity of cleanup benefits across the 258 sites.

These two studies did not attempt to estimate the value of other health or non-health outcomes stemming from land contamination and thus indicate only a partial measure of the potential benefits of land cleanup.

Lamentably, risk exposure data for many contaminants or contaminant mixtures do not exist and if a site is unique—not belonging to a set of similar sites—a risk assessment might be impractical. In addition, what risk information is available is often inappropriate for valuation.

The toxicological literature routinely provides data only from the tails of the risk distributions for different chemicals. For many carcinogens, analysts know only the exposure resulting in 95 percent confidence that vulnerable populations will be safe. For non-carcinogens, available risk information is on the dosage or concentration that should not be exceeded in order to protect human health. Thus, information on health risks experienced by the population on average, which would be most useful for benefits estimation, is often unavailable.

Sometimes risk information is derived from animal rather than human studies. Translating animal exposure information into human risk data adds an extra layer of uncertainty. Epidemiological data provide some information on human exposure but are scarce, and it is difficult to draw statistically meaningful inferences from epidemiological data when sparse populations surround contaminated sites. It might also be inappropriate to combine such data with distance from the site as a proxy for exposure. Thus, risk data might not easily translate into an estimate of the number of adverse health outcomes in a population surrounding a cleanup site. Box 6.1 underscores some of the complexities of undertaking risk assessment to evaluate site cleanup.[36]

Risk assessments often focus on human health, but they can also examine the effects of contaminants on ecosystems. Ecological risk assessments illuminate the physical effects of cleanup activities on animal or plant populations, species or ecosystems using biological models. However, data on ecological risks posed by land contaminants is even sparser than health information, particularly data that can be linked to measures of human welfare that are necessary for economic analysis. A recent Science Advisory Report on ecological risk assessment discusses some of the challenges in developing risk assessments for contaminated sites (U.S. EPA 2007b).

While risk assessment data could be used to measure the benefits of land cleanup, it is less useful for assessing the potential benefits from site reuse. In addition, because risk assessments typically focus on a few health outcomes, they can neglect many potential health and non-health benefits. Additional approaches to valuing the benefits of site redevelopment might be used in tandem with risk assessments to estimate the full benefits of cleanup and reuse.

Due to the challenges posed by the multitude of contaminants and exposure pathways present at contaminated sites and the paucity of appropriate data, risk assessment is often impractical for measuring the benefits of cleanup, especially when the sites are unique. Examples of sets of similar sites might be land associated with CCR waste management units or LUSTs at gas stations. Risk assessment is also not particularly useful for assessing reuse. Finally, analyses that must be completed within a short period of time are not well-positioned to rely on risk assessment if appropriate health effects data are unavailable (Smith 2007). Instead, for the land cleanup scenario, economists frequently avoid the necessity for risk information by estimating WTP for distance from a site rather than WTP for a specific reduction in health risk, a simplification that is discussed further in Section 6.3.1.1.2.

[36]For a discussion of how to design risk assessment to be useful as an input to benefit cost analysis see Dockins et al. (2004).

6.2.1 Advantages, Limitations and Recommendations

Risk assessment is well-developed in contexts where a small number of contaminants affect a few health or ecological outcomes. It is most suitable to the land cleanup scenario when there are a sizable number of similarly contaminated sites; otherwise the time and effort necessary could be prohibitive. A small number of contaminants or a large number of similar sites are not necessarily typical for contaminated land; thus its applicability to the land cleanup arena is limited. Below, the advantages and limitations of the risk assessment approach are summarized for analysts studying land cleanup activities and provide a few recommendations.

Advantages

- Risk assessment can provide analysts with information about the biophysical effects of land cleanup.
- Risk assessment is useful when analysts can obtain risk reduction, characterization and population exposure information about the site.
- Risk assessment can be used for prospective analysis.

Limitations

- Risk assessment is difficult to apply to sites plagued by multiple contaminants and exposure pathways. Models for assessing the risks of multiple stressors are not well developed.
- Gathering the necessary data from different sources can be costly and time-consuming if applicable risk studies are not already available. Data necessary for ecological risk assessments in particular might be unavailable.
- Risk assessment does not provide information about the social benefits expected from reuse activities.

Recommendations

- Choosing the most threatening contaminant and pathway, and settling for cost of illness rather than WTP estimates can improve practicality of valuing risk reductions from land cleanup.
- Risk assessment becomes more useful in the face of a sizeable number of similarly contaminated sites.

6.3 Economic Valuation Methods

As discussed in Chapter 5, general equilibrium analysis examines all changes in an economy resulting from a policy or program and holds potential to provide a comprehensive assessment of cleanup and reuse benefits, but it is currently limited by a lack of practical methods. A number of partial equilibrium approaches hold more immediate potential for estimating land cleanup and reuse benefits. In particular, property value models and SP surveys have dominated the valuation of land cleanup and reuse benefits. This section focuses on these two methods, but also covers several other methods that could be relevant for benefits assessment. While Chapter 7 of the *EA Guidelines* discusses many of these approaches, the purpose of this section is to detail how each applies to land cleanup and reuse. It outlines the advantages and drawbacks of each and provides recommendations to help analysts determine which methods are most relevant to the activity, program, site and/or benefit category under study.

Although there is some overlap in the types of benefits, sites and activities that can be evaluated with the different approaches, their strengths and weaknesses make each more suitable for different applications. Some methods can be used in concert with health or ecological risk assessments, discussed above. Programs focusing on lengthy as compared to quick cleanups, those with a focus on reuse as opposed to cleanup alone, or sites where the public is well informed about health risks versus sites where they are not, might call for different approaches. Since the methods focus on somewhat different categories of welfare changes, they are expected to yield different benefit estimates. Jenkins et al. (2006) reviewed several studies that have applied these methodologies to valuing effects of land cleanup.

This section summarizes the feedback received from the participants in the 2006 EPA workshop on “Methods for Estimating the Social Benefits of EPA Land Cleanup and Reuse Programs” (Smith 2007). The workshop highlighted ongoing disagreement among economists regarding which methods are most appropriate for valuing the benefits of different land cleanup and reuse activities. Workshop participants felt that property value and SP methods remain promising, but that their full potential has not yet been realized by existing studies.

This section particularly highlights recent advances in the literature on property value models pertinent to land cleanup benefits. Because of this focus on new methods, the section devotes somewhat more space to property value models than to SP or other valuation approaches. This emphasis is not intended to imply that analysts should focus attention on property value approaches to the exclusion of other methods.

6.3.1 Property Value Analysis

The analysis of property values is a popular method for assessing the effects of land cleanup and reuse. A variety of models, representing a range of impacts and assumptions, exist in the current literature.[37] In contrast to risk assessment-based models, multiple contaminants and exposure pathways pose less of a problem because property price models capture the aggregate effects of the cleanup and/or reuse effort on real estate prices. This aggregate effect can encompass a broad array of direct and indirect use benefits (though not nonuse benefits), including perceived human health effects, amenities and aesthetic benefits, certain ecological improvements, agglomeration, and peer-group effects. Property value studies can also focus on different types of properties, whether residential, commercial or industrial. Analysis of property data usually allows for a more rapid benefits assessment than SP methods, which require gathering data from original surveys.

[37] Some analysts might be familiar with property value studies from the professional appraisal literature assessing land cleanup and reuse. They focus on measuring impacts on private real estate markets rather than using property values to measure social benefits of cleanup and reuse such as improved health and amenities. Thus, appraisals and benefit assessments use property value analysis for distinctly different objectives. In addition, appraisal approaches often use different methods and assumptions than economic benefits studies. (See Bell 2008 for a summary of common appraisal methods.) These different assumptions could, in some instances, be applicable in an EIA. For example, appraisers consider the effects of incentive programs like cleanup grants on property values, since their value accrues to the property owner. A cleanup grant would not factor into a benefits analysis because it represents a transfer of resources from taxpayers to property owners rather than a net gain to society, but the redistribution of resources might be relevant in an EIA. In general, analysts conducting either BCA or EIA are urged to follow methodological guidance from the environmental economics literature rather than appraisal studies when the two diverge.

Property value models are better suited to certain situations than others. Property prices only reflect the benefits and risks that owners and potential buyers are aware of and concerned about. For instance, property prices only capture health benefits about which market participants are well-informed. Accurate or complete information may not be available until after a site has been investigated and the findings announced to the public. The discussion of stigma in Chapter 4 highlights some of the difficulties in understanding the interaction between information and consumer perspectives. Property value models are also vulnerable to empirical challenges, such as omitted variable bias.

Property value studies have targeted a variety of land cleanup policies and questions. Many papers have examined Superfund sites (Deaton and Hoehn 2004, Greenstone and Gallagher 2008), while others have analyzed non-NPL hazardous waste sites (Ihlanfeldt and Taylor 2004) and other undesirable land uses (Nelson 1981, Nelson et al. 1992, Smolen et al. 1992, Lim and Missios 2007). Property value models have been used less extensively to study land reuse than contamination or cleanup, though the approach holds promise for examining reuse as more data from sites past the remediation stage become available.

Many traditional property value studies use the hedonic approach, which has its theoretical foundation in Rosen (1974). Rosen describes an equilibrium model of interaction between utility maximizing consumers and profit maximizing producers in a market for a heterogeneous good (one composed of multiple attributes, such as a home or car). An advantage of this model is that the marginal "price" of an attribute is equal to a person's marginal WTP for that attribute.[38] Although this feature is particularly useful for policy analysis, several strict criteria must be met for it to apply. Of particular relevance to land cleanup, the hedonic model is designed for *marginal* changes. While appropriate for measuring changes in proximity to a hazardous site, the hedonic model is not as well-suited for measuring the much larger impact of a site transitioning from contaminated to remediated.

Several alternatives to the hedonic model have seen increasing use in recent years. These approaches are sometimes called "capitalization" studies because they estimate the extent to which changes in amenities are capitalized into property prices over time, but as discussed below, this capitalization effect does not always represent WTP. Capitalization models include repeat sales models (Case et al. 2006), which compare sales of the same home over time, as well as difference-in-difference and other quasi-experimental methods (Davis 2004, Pope 2008, Greenstone and Gayer 2009).[39] Although the estimates produced by these models do not always equal WTP, they can still be informative tools for policy analysis. The subsections below discuss issues involved in estimating and interpreting the results of these different approaches to property value analysis.

[38] Palmquist (2005) is a good resource for readers looking for more background on the theory and practice of hedonic property models for valuing environmental amenities.

[39] Equilibrium sorting models provide a still more recent alternative to hedonic and capitalization studies in the property value literature. These models explicitly account for residential sorting behavior and consider resulting changes in a variety of neighborhood amenities to capture general equilibrium welfare impacts of the type discussed in Chapter 5. The *Handbook* does not cover equilibrium sorting models due to their novelty and lack of application to date in the land contamination and cleanup literature, but they remain a promising area for future research. Kuminoff et al. (2010) provided a thorough treatment of these models, and applications in environmental economics include Tra (2010) and Walsh (2007).

6.3.1.1 Estimating the Effect of Land Cleanup and Reuse on Property Values

There are several ways to use property value data to estimate the effects of a change in an environmental amenity or disamenity. Table 6.2 summarizes the main approaches and highlights some of the defining features of each. This section discusses estimation issues with each approach and provides several examples. The reader is encouraged to browse the recommended sources for further information and estimation details.

The first method in Table 6.2, and the most commonly encountered in the land literature, is the hedonic model. Rosen's (1974) hedonic model has seen considerable application in environmental economics. In Rosen's theoretical model, the equilibrium between consumer bid functions and producer offer functions yields the hedonic price function. A consumer bid function is the maximum amount a consumer is willing to pay for a good for a specified level of utility. The producer offer function represents the minimum price a producer would accept to sell a good at a certain profit level (Hidano 2002). The hedonic model was designed to be used with cross-sectional data, which reflect the market equilibrium at a particular point in time. This is a critical feature, since datasets spanning a wide range of time may not reflect a marketplace in equilibrium.

Several widely-cited papers in land cleanup literature have used the hedonic approach, most focusing on sites listed on the Superfund NPL. Michaels and Smith (1990) examined NPL sites in the Boston, Massachusetts area, Kiel (1995) looked at NPL sites in Woburn, Massachusetts, Ihlanfeldt and Taylor (2004) studied non-NPL hazardous waste sites in Atlanta, Georgia and Kiel and Williams (2007) looked at property value responses to 57 NPL sites across the United States. Jenkins et al. (2006) reviewed several additional hedonic studies of land contamination and cleanup.

Table 6.2 - Property Value Estimation Table

Property Value Model	Data	Interpretation of Coefficient Estimate	Potential Controls for OVB	Examples
Hedonic	Cross section	Marginal WTP	Spatial fixed effects, IV	Michaels and Smith (1990), Ihlandfelt and Taylor (2004), Kiel and Williams (2007)
Repeat sales	Panel	Capitalization	Property fixed effects, IV, DID	Gayer and Viscusi (2002), Case et al. (2006)
Quasi-experimental	Panel or pooled cross section	Capitalization	Regression Discontinuity, DID, IV, and property or spatial fixed effects	Davis (2004), Greenstone and Gallagher (2008), Gamper-Rabindran et al. (2011),

Definitions: WTP = Willingness to Pay, IV = Instrumental Variables, DID = Difference in Difference

6.3.1.1.1 Omitted Variable Bias

A large problem in property price models (and econometrics in general) is omitted variable bias (OVB). This occurs when variables that are not included in the model are correlated with those that are, which can bias results.[40] Due to the spatial nature of property sales and the importance

[40] Omitted variables are one potential cause of endogeneity in econometric models. An independent variable is endogenous if it is correlated with the error term of the regression model, causing the coefficient estimate to be

of structural and neighborhood amenities, OVB can be particularly problematic in property value analysis (Abbott and Klaiber 2010). For instance, Deaton and Hoehn (2004) found that hazardous waste sites are often located in industrial areas characterized by several common disamenities, including rail traffic, air pollution, and industrial noise. If the analyst does not control for these confounding factors, the coefficient for the hazardous waste variable may pick up their impact and overestimate the effect of hazardous waste. Several methods have arisen to deal with this problem, although there can be a tradeoff between the interpretation of the results and the corrections for OVB, as discussed in the next section.

In hedonic models, the most popular way to deal with the problem is through spatial fixed effects or similar indicators such as dummy variables for a school district or housing subdivision. If properly specified, spatial fixed effects can be used to account for unobserved attributes (Kuminoff, Parmeter, and Pope 2010). However, spatial fixed effects should not be seen as a comprehensive solution to the problem of OVB. Abbott and Klaiber (2010) cautioned that fixed effects must be specified at the correct level of granularity to capture the proper unobserved influences; for example, if census tract fixed effects are used to control for unobserved characteristics in an analysis of land contamination, there must be variation in exposure to land contamination *within* the census tract to estimate its impact on property values. In many cases, these fixed effects are not enough to properly account for OVB because important unobserved characteristics correlated with land contamination could also vary within the census tract or other spatial unit. (See Smith 2011 for additional discussion of this issue.)

An alternative method of controlling for OVB involves the use of repeat sales—the second approach in Table 6.2. Repeat sales models compare changes in home prices and attributes over time for the *same* house. The advantage of this approach is that unobserved attributes will likely be constant between the two home sales and are effectively addressed (as long as significant time has not elapsed between sales). For example, Case et al. (2006) used repeat sales to explore ground water contamination in Arizona. There are, however, some problems with the repeat sales approach. Since only homes that sold more than once are used in the analysis, the sample may not represent the true distribution of homes and attributes. For instance, “lemons” because they are likely to have greater owner turnover, may be overrepresented in the sample. Meese and Wallace (1997) examined a repeat sales model and found that it suffered from sample selection bias and was very sensitive to influential observations.

Moving to the third entry in Table 6.2, quasi-experimental study designs are a popular recent alternative for confronting OVB in property value models. The basic approach is to identify a “natural experiment,” such as the passage of a law or discovery of contamination. The idea is to mimic a lab experiment, comparing randomly “treated” and “control” populations before and after a treatment. Even though the event may not be random in its assignment process, it may still be possible to draw valid inferences from it (Greenstone and Gayer 2009).

As explained by Greenstone and Gayer (2009), there are three main approaches to quasi-experimental analysis, though they are not mutually exclusive and are frequently used in tandem. The first is the Difference in Difference (DID) model. DID requires data from at least two groups (a treatment and a control group) and two time periods (before and after a policy change or other

biased. Other possible causes of endogeneity that can bias regression results include measurement error and simultaneity.

natural experiment has occurred). For instance, discovering that homes next to a gas station have been exposed to leaking contaminants through their well water, while another group of similar homes nearby remains unexposed, might provide a good natural experiment for DID. The analyst would calculate the change in property prices in the treated group before and after discovery. Then the analyst would subtract the change in property prices over the same period for the non-treated group, hence the "difference in difference." The regression model can be estimated using fixed effects, as shown in Davis (2004) and Parmeter and Pope (2009), and can use either repeat sales data or a pooled cross section that compares the sales of different homes at different points in time. Ideally, the analyst would include data on the initial level of the disamenity in the analysis as well as the change in the disamenity. Unfortunately, such data are frequently unavailable in the context of land cleanup and reuse, as analysts might only know whether a site is "contaminated" or "cleaned up" but have little information on actual contamination or exposure.[41]

The second quasi-experimental approach involves instrumental variables (IV). The objective of an IV analysis is to find a variable (the "instrument") that is correlated with the treatment (in this case, either land contamination or cleanup), but uncorrelated with the outcomes of the natural experiment (property prices). Through a two stage least squares regression, the instrumental variable can purge the bias from the equation. For example, Chay and Greenstone (2005) used county-level nonattainment status with the Clean Air Act as an instrument for total suspended particulates to estimate the impact of reducing air pollution levels on housing values. This was needed since there were unobserved selection effects biasing the regression. For a general treatment of IV regression, see Angrist and Kreuger (2001), Levitt (1996) and Murray (2006); for tests of instrument validity and related issues, see Nelson and Startz (1990), Hahn and Hausman (2002), Stock and Yogo (2002), and Hahn and Hausman (2003).

The third quasi-experimental approach uses a regression discontinuity (RD) design to address OVB. In this method, sorting into the treatment or control groups is based on some form of "cutoff" value in an observed continuous variable. For instance, assignment to the Superfund NPL when the program started in 1982 was based on whether the hazard ranking score was above 28.5, a threshold that was only determined after sites were evaluated (thus minimizing any opportunity to manipulate the scoring to ensure that certain sites would make the list). Because observations on both sides of the cutoff were likely to have been similar, Greenstone and Gallagher (2008) exploited this discontinuity to approximate a naturally-occurring experiment. Box 6.2 provides additional information on Greenstone and Gallagher and other studies that illustrate quasi-experimental approaches to estimating the impacts of land cleanup on property values. For additional information on the theory and application of quasi-experimental methods in property price models, see Parmeter and Pope (2009).

[41] Banzhaf's peer review comments on the draft *Handbook* (Smith 2011) noted that it is important to include the initial level of the amenity in a DID regression because individuals' preferences for cleanup could change with the severity of contamination (e.g., a reduction in contamination from a very high level to a moderate level might be valued more highly than reducing contamination by the same amount but from a moderate to a low level). However, it is only possible to include both the initial level of contamination and the change in the DID regression model if contamination is measured as a continuous variable that varies before and after cleanup. If the analyst only has data on distance to a site, which does not vary before and after cleanup, it is not possible to examine the impacts of both the initial level of contamination and the cleanup on property values.

Regardless of the approach used to address OVB, it is important to verify the similarity of the control and treatment groups or observations being compared. A comparison of means and variances for key variables such as neighborhood demographics is one simple approach (Smith 2011).

BOX 6.2 – QUASI-EXPERIMENTAL APPROACHES TO ESTIMATING PROPERTY VALUE MODELS

A few recent studies have applied quasi-experimental approaches to property value models to analyze land cleanup and other environmental policy issues. Greenstone and Gallagher (2008) used a regression discontinuity research design to study the Superfund remedial program. Regression discontinuity can be applied when participation in a cleanup program depends on an observed variable crossing a fixed threshold that is unrelated to property values. This threshold serves to "randomize" whether or not a site joins a cleanup program. When the NPL was first created in 1982, over 600 contaminated sites were scored using the Hazard Ranking System (HRS), but only 400 sites—those scoring at least 28.5—were eventually listed due to budgetary constraints. The authors compared the change in median housing values between 1980 and 2000 in census tracts with sites that were listed to the NPL to the change in values in census tracts with sites that just missed the cutoff. Since sites above the threshold likely posed similar hazards as those just below, sites that narrowly missed the NPL provide a good control group. In addition, because some of the sites were later rescored and their NPL status changed, the authors employed an instrumental variables approach to control for the potential that rescoring was not random; for example, if community involvement spurred rescoring in neighborhoods experiencing above-average economic growth. An original 1982 HRS score of at least 28.5 was used as the IV for final assignment to the NPL. Results of the study showed no significant effect of NPL listing on the change in property values or rental rates.

A working paper by Gamper-Rabindran et al. (2011) built on the Greenstone and Gallagher study to assess the effects of Superfund cleanups by comparing housing values located near sites proposed to, listed on, and deleted from the NPL using a difference-in-difference approach. Their analysis focused on lower-decile property values within each census tract instead of median values, finding evidence that these properties are typically located closer to Superfund sites. They also examined property values in census blocks, a much finer scale of resolution than tracts, comparing the change in value in blocks with sites deleted from the NPL to the change in value in blocks with sites that were either listed or just proposed. The authors found a statistically and economically significant increase in housing values in response to site cleanup in the census block analysis and in lower-decile properties in the census tract analysis.

Other studies less directly relevant to land cleanup still offer insights for using quasi-experiments in policy analysis. For example, Davis (2004) examined the effects of a cancer cluster on property values to estimate marginal willingness to pay to avoid cancer risks. The author used a difference-in-difference study design, comparing the change in housing prices before and after an unusual spike in childhood leukemia rates in an isolated Nevada county to the change in housing prices over the same period in a nearby county that was similar in terms of demographic and labor market characteristics, making it a valid control group. The unexpected occurrence of the cancer cluster minimizes the potential for omitted variables influencing both cancer risks and residents' locational choices prior to discovery. The author found that houses affected by the cancer cluster sold for about 15 percent less than equivalent houses in the control county. Although there is still no evidence linking contamination to the elevated cancer risk, this study illustrates the types of natural experiments that can help researchers identify causal effects associated with contamination events and the public policies addressing them.

6.3.1.1.2 *Other Estimation Issues*

Another important estimation topic is the representation of the disamenity in the property price model. The ideal measure of the externality is exposure to health risks or other disamenities (e.g., odor), but this information is frequently unavailable. Instead, analysts often use distance to a contaminated site as a proxy for exposure. For instance, Kiel (1995), Deaton and Hoehn (2004), and Ihlanfeldt and Taylor (2004) included distance to a site in their regression analyses, while Zabel and Guignet (2010) sorted homes into concentric rings radiating from the site.

The distance measure relies on house-specific distance data. When more aggregate data are used, analysts can examine how median housing values in census tracts vary with the number of contaminated sites, as seen in Greenberg and Hughes (1992) and Greenstone and Gallagher (2008). One difficulty of this approach is that census tracts can be large and internally heterogeneous, so the average or median home within a tract may be a safe distance from the environmental disamenity. A working paper by Gamper-Rabindran et al. (2011) (discussed in Box 6.2) partially addressed this problem by examining lower-decile housing values within census tracts, which are sometimes located closer to contaminated sites, as well as higher resolution census block data. Additionally, there may be multiple sites of varying risks in a particular tract, which can be hard to capture in a regression analysis.

Approximating a home's exposure to disamenities with distance to a site or location in the same census tract as one or more sites can raise problems for analysts estimating the effects of land contamination or cleanup. For example, contaminated ground water plumes rarely travel uniformly in all directions from the contamination source and do not adhere to administrative boundaries like census tracts. Cameron (2006) found that the direction in which distance from a site is measured can have a significant effect on the result. If the distance measure is a poor proxy for the disamenities associated with the site, then this implies that exposure to the disamenity is measured with error in the regression equation. This measurement error could produce estimates that are biased toward zero due to attenuation (Greene 2000).

A few studies have attempted to go beyond simple distance proxies to use measures of land contamination status that better reflect either actual or perceived exposure. A recent working paper examining LUSTs used well testing as one indicator of contamination and found that homes near leaking USTs where wells were tested for contamination experienced price drops, while those near leaking USTs where wells were not tested saw no change in prices (Zabel and Guignet 2010). Gayer and Viscusi (2002) investigated the connection between local newspaper coverage of hazardous waste sites and home prices, since local media reports can be the channel through which residents and homebuyers are informed of risks and can play a significant role in the home purchasing decision.

The functional form of the property price regression is another important issue. The simplest functional form is a linear specification, where the home price is the dependent variable and all independent variables appear linearly on the right side of the regression. More complicated functional forms are commonly used, where variables enter in natural log, squared, or other forms. Although past research favored simpler functional forms in the presence of omitted variables (Cropper et al. 1988), more recent research indicates that a more thorough approach to selecting the functional form is needed (Kuminoff et al. 2010). Analysts should explore several different functional forms, based on theory and the aforementioned citations. The flexible Box-Cox model (Greene 2000) represents a popular method for testing functional form. When a linear rather than log specification is used in a model with transactions from multiple years, analysts must be sure to use real rather than nominal price data to control for inflation.

A final estimation topic is spatial dependence (or spatial autocorrelation), which occurs when the correlation between two observations depends on a spatial relationship or location. Since home sales are distributed across a spatial landscape, spatial dependence is common in property value analysis. Home prices normally depend on other nearby home sales, and homes in close proximity are influenced by similar unobserved neighborhood or geographic attributes (Anselin 1999, Anselin 2001). Spatial dependence can bias the coefficient estimates or the standard error estimates in a property price regression, as well as result in inefficient coefficients, since the non-spatial approach does not account for these relationships. The two most common approaches to controlling for spatial dependence are the spatial lag model (Anselin 1999, Kim et al. 2003) and the spatial error model (Bell and Bockstael 2000, Leggett and Bockstael 2000), as well as combinations of the two (LeSage and Pace 2009, Wu and Cutter 2011). Several tests, including the Moran's I, Lagrange Multiplier, and robust Lagrange Multiplier can be used to detect spatial dependence (Mueller and Loomis 2008, LeSage and Pace 2009).

6.3.1.2 Interpreting the Estimates from Property Value Models

The previous section discussed methods and considerations for obtaining credible estimates of the change in property values caused by land contamination or cleanup. A related issue is how to interpret these estimates—specifically, understanding when an estimate of a change in property values can be interpreted as a measure of the benefits of land cleanup and reuse. As already discussed, studies that rely on cross-sectional data and examine distance to a contaminated site as a proxy for exposure must be interpreted cautiously because moving farther away from a site might not be equivalent to cleaning it up in terms of health risks, aesthetics and other characteristics. It is also difficult to use estimates from cross-sectional models based on distance to assess the benefits of partial site cleanup (Smith 2011).

Studies that compare housing prices before and after cleanup using repeat sales and quasi-experimental approaches raise particular challenges for interpretation. A change in property values resulting from land cleanup implies that the housing market has "capitalized" the improvement in environmental quality. However, as discussed below, the capitalization effect is not always equivalent to WTP for the cleanup.

The capitalization estimate from repeat sales and quasi-experimental models represents the average rate of change in property values that occurs in response to a change in an amenity. This estimate only equals WTP for cleanup if the marginal WTP remains stable over the study's time horizon (Kuminoff and Pope 2010, Smith 2011). If marginal WTP for cleanup is increasing over time in the study area, then the capitalization estimate will tend to overestimate the benefits of cleanup. An example of this situation might be gentrification or re-sorting of residents such that people with a higher WTP for environmental quality move closer to the site, causing pre- and post-cleanup housing prices to reflect the preferences of two distinct groups of people. Conversely, if marginal WTP is decreasing over time—which might occur if many cleanups take place, and residents' incremental WTP for cleanup decreases with the total number of cleaned sites or amount of remediated land—then the change in prices estimated after cleanup will underestimate the benefits of cleanup.[42] It could be particularly difficult to predict the direction of bias if several of these effects are happening simultaneously. The bias introduced by these changes over time can be significant; for example, a working paper by Kuminoff and Pope (2010) reported that the change in property values in five urban areas underestimated WTP for improved public school quality by 400 percent.

[42] Kuminoff and Pope (2010) derived the theoretical relationship between capitalization and marginal WTP. Banzhaf's peer review comments on the draft *Handbook* provided a simple numerical example (Smith 2011). The comments also suggested that the bias in panel data models can be corrected by including the initial level of the disamenity as well as the change in the disamenity as variables in the regression model. However, as already discussed, this is often infeasible due to data limitations when studying land cleanup.

If residents do not re-sort, their preferences and incomes are not changing over time, and their marginal WTP for cleanup does not depend on the total amount of cleanup, then a capitalization estimate can be interpreted as a measure of cleanup benefits accruing to nearby residents. These assumptions might be reasonable for studies covering relatively short periods of time and examining small changes in environmental quality. Analysts might be able to gather evidence suggestive of whether preferences or populations are changing over time by examining whether the demographic composition of the study area has changed.

Another issue complicating the interpretation of capitalization estimates occurs if land cleanup has significant enough effects on the entire property market to cause price changes in other neighborhoods or towns not directly affected by the site, resulting in a new equilibrium schedule of property prices (as discussed in Section 5.3). In this situation, nearby neighborhoods might not serve as an appropriate control group for baseline housing market conditions if their prices are affected by pecuniary spillovers from the cleanup program.

If analysts can qualitatively infer the likely direction of bias, then they can at least determine whether a capitalization estimate represents either an upper or lower bound on cleanup benefits. Even if capitalization estimates cannot be definitively linked to individuals' WTP, they can still provide evidence on whether the property market values cleanup, which is a useful piece of information for policymakers. The magnitude and direction of the bias in using capitalization estimates to measure benefits is still an area of active research.

Also important for interpretation is whether property value models estimate the effect of marginal or large-scale changes in land contamination. As noted in Table 6.2, certain models are appropriate for estimating marginal changes, while others are better suited for examining non-marginal changes. Difference-in-difference and quasi-experimental studies often compare large changes. Traditional hedonic studies can only estimate the effect of marginal changes in a continuous measure of an amenity. However, the estimates from multiple hedonic equations that each use data from different time periods could be used to examine large changes by comparing WTP to live farther from a contaminated site before and after cleanup (e.g., Kiel and Williams 2007). Parmeter and Pope (2009) showed that the coefficients from property value studies using difference-in-difference and RD models represent *average* rather than marginal WTP for environmental quality (as long as the condition on the stability of preferences over time is met). Average and marginal WTP will only be equal if the hedonic price function is linear in environmental quality. When studying NPL site cleanups in particular, comparing a heavily contaminated site before and after cleanup, or comparing a site that remains contaminated and another site that has undergone cleanup, is unlikely to reflect WTP for *small* reductions in land contamination. Estimates of the value of both large and marginal changes can inform policy analysis, but it is important to be aware of which is being measured and interpret the results accordingly. Only marginal benefits can be compared with marginal costs to determine whether a policy maximizes net social benefits, while average WTP is most useful for calculating a policy's total net benefits.

A more general issue affecting the interpretation of estimates from property values studies and other revealed preference approaches arises when there is uncertainty about the risks posed by a contaminated site. As discussed in Section 6.2 on risk assessment, quantifying the exposure risks from contaminated land is complicated by the diversity of potential media, pathways and health effects involved. If homebuyers do not know with certainty the risk reductions achieved by remediation, and researchers lack information about their perceptions of these risk reductions, property value model estimates might not be appropriate measures of the health benefits of site cleanup. Just (2008) has suggested eliciting information about risk perceptions in tandem with revealed preference studies as one approach to help identify estimates of WTP for improvements in environmental quality or other public policies.

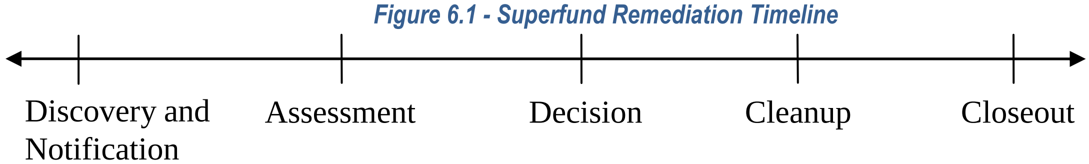
Once analysts can interpret how estimates from property value models relate to land cleanup and reuse benefits, they must still determine when and how the results from these studies can be generalized and used for policy analysis. Section 6.3.4 on benefit transfer addresses this topic. The timing of events along the cleanup timeline is a final key issue affecting the interpretation of property value model estimates discussed below.

6.3.1.2.1 Timing of Significant Events

A key component of how to interpret the estimates from property value studies concerns the treatment of the cleanup timeline. The appropriate timeframe for analysis of land cleanup based on property values is an issue that has yet to be resolved by experts in the field.

Due to the difficulty in assessing whether cross-sectional site proximity can be used to estimate the benefits of site cleanup, panel data—including observations before, during and after cleanup—have become important for contributing to the understanding of cleanup and reuse benefits. The phases of the cleanup process covered by the data should be taken into consideration. Superfund remedial actions illustrate the complexity of the issue. Figure 6.1 presents a typical timeline of activities, illustrating the many stages at which property prices could fluctuate and calling attention to the challenging task of identifying an appropriate baseline and follow-up period for analysis. Further complicating matters, reuse activities could begin at any stage on the timeline.

Figure 6.1 - Superfund Remediation Timeline



Source: Fundamentals of Superfund (U.S. EPA 2007c)

Although many studies have included data from more than one point on this timeline, few have covered the entire time period from pre-discovery to completed cleanup. Revisions to the hedonics discussion of the Superfund Benefits Analysis concluded that while many studies have found NPL sites to affect residential property values, the magnitude and direction of the impact varies, information on timing of effects is unclear, and studies have rarely focused on timeline as an issue of interest (U.S. EPA 2008). Jenkins et al. (2006) reviewed several studies of NPL sites including different points in time and found no consistent results as to when or whether housing prices dropped and then rebounded. Some studies have revealed initial price drops after discovery, while others have found no negative effect until after the site is listed. Conversely, prices might rebound soon after listing in anticipation of cleanup work; they might not recover until cleanup has commenced or finished; or if stigma is persistent, they might remain depressed indefinitely. If erroneous or unfounded beliefs about contamination drive initial price shocks, the appropriate baseline might be after risk assessment results are publicized (U.S. EPA 2006a). The appropriate baseline and follow-up period might also depend on the cleanup program under study. Cleanups with very short timeframes, such as Superfund removal actions, might be difficult to analyze using property value models if very few properties change hands between discovery and completion of the removal.

One hedonic study that paid special attention to significant events along a timeline examined three Superfund remedial sites and showed that property values dropped after discovery of contamination, bounced back when listed on the NPL, but then fell again during cleanup activities (Messer et al. 2006). The results suggested that recovery might not occur for several years after cleanup is completed. The authors concluded that long delays between discovery and cleanup could erode the discounted present value of remediation efforts if housing prices do not recover until after the lengthy cleanup effort is complete. Kiel and Williams (2007) were careful to account for significant events along a timeline as well and found that the reaction of property prices to different events varied across Superfund sites. Gamper-Rabindran et al. (2011) also found that the impact of milestones along this timeline varied considerably across metropolitan areas. Still, their national-level analysis showed a significantly greater rise in property values near sites after deletion from the NPL compared to the period after proposal or listing.

Many property value studies have paid insufficient attention to the timeline of significant events, and the dearth of studies incorporating post-cleanup data precludes drawing conclusions about the appropriate follow-up period. It is important to clearly identify the timeline of site-specific events and incorporate data from several points on this timeline into the analysis, since the timing of the effect of land cleanup activities on property values can vary from case to case. In order to determine the effect of an entire cleanup project, analysts would need data at many points, potentially including pre-discovery, notification, assessment, selection of the remedy, and so on. (However, as noted above, estimates from studies covering long periods of time can be difficult to interpret if the public's preferences for site cleanup are changing, or if residents move around in response to the cleanup.) If reuse benefits are of particular interest, data covering the period following reuse are essential. In practice, it might be infeasible to access data from each point on the timeline, but it is crucial to recognize that the time period reflected in the data has important implications for interpreting the results.

6.3.1.3 Analysis of On-site Benefits

Thus far, the discussion of using property value models for measuring benefits has focused on the effect of cleanup and reuse activities on properties located near contaminated sites. A number of studies have also used property value models to examine the effect of contamination, cleanup and reuse on the contaminated properties themselves.

Several empirical studies have found evidence of a "contamination discount" and post-cleanup price rebound (e.g., Howland 2000, Howland 2004, Jackson 2002, Alberini 2007). However, caution must be taken when interpreting these results for benefits analysis because pre-cleanup property prices of contaminated sites reflect the liability for cleanup costs and other risks associated with resale and redevelopment of a contaminated property, in addition to the pre-cleanup use value of the site (U.S. EPA 2006a). In other words, a jump in price after cleanup could result not only from an increase in the stream of future earnings from the site, but also from the value of reduced liability and cleanup costs that no longer burden the property owner. Thus, the cleanup coefficient estimate from a property value model conflates on-site benefits with remediation costs.

Because of this issue, sales data from the pre- and post-cleanup period, as well as information on actual or expected cleanup costs, are needed to estimate on-site benefits. The necessary data on transaction prices are often unavailable due to low sales rates among contaminated properties, which could occur due to liability issues or simply because a property's post-cleanup use value might not exceed cleanup costs, in which case no rational buyer would purchase it in the absence of subsidies. Of course, total social benefits (including off-site benefits) could still exceed cleanup costs in this situation. It is not appropriate to assume that properties with no pre-cleanup transactions are similar to those that do sell and to apply benefit estimates from sold properties to obtain a measure of on-site benefits for sites that do not change hands.

When information on property values or prices is available but data on cleanup costs are not, analysts can include a proxy like the probability of contamination in the regression model (McGrath 2000).[43] On-site benefits can be calculated by subtracting the estimated discount in property prices due to liability from the estimated increase in property prices due to cleanup. Interpreting the property value model coefficient of cleanup status on property prices without accounting for remediation liability would overestimate the benefits of site cleanup by counting cleanup costs as benefits.

In the special case in which properties sit vacant or unused prior to cleanup, analysts might be able to make the simplifying assumption that the property has no positive use value without remediation. Assuming that pre-cleanup use value is approximately equal to zero obviates the need for sales data during this period. In this situation, the prevailing price following cleanup and redevelopment, which reflects the new use value, represents the on-site benefits of cleanup and reuse activities. Thus, only data from the post-cleanup period are necessary to estimate the on-site benefits, and a hedonic model is not required to isolate the value of cleanup, since its entire value can be attributed to the cleanup and reuse activity. Analysts should be cautious about adopting this assumption. Justification is needed for the assertion that the site has no use value prior to remediation and redevelopment.

6.3.1.4 Analysis of Property Transaction and Vacancy Rates

As discussed in Section 6.1.5.1, imperfect information may dampen the sales rates of contaminated or nearby properties, leading to fewer transactions. In addition, in communities with high vacancy rates, increased demand for properties resulting from remediation could lead to a higher occupancy rate rather than an increase in prices near the site (Smith 2011). This situation can affect the interpretation of benefit estimates if the properties that sell are not representative of all those affected by the cleanup effort. A Science Advisory Board panel recommended revising a hedonic meta-analysis of the Superfund program to consider whether distance from program sites affected property transaction rates as well as sales prices (U.S. EPA 2006a).

[43] McGrath (2000) included the probability of contamination (based on the site's historical land use) in a hedonic analysis of properties slated for redevelopment to estimate the contamination discount capitalized into sales prices. The coefficient estimate can be interpreted as reflecting anticipated remediation, legal and other costs associated with contamination.

An examination of the effects of contamination and/or cleanup on property transaction and vacancy rates could shed light on these issues.[44] Such an analysis could be a useful supplement to an examination of property prices, though it should not serve as a substitute since a change in property transaction rates is not in itself a measure of social benefits. If contamination status has no significant impact on the sales rate, then "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 already stated, studies that show contamination depresses sales rates do not conclusively prove that cleanup programs have the opposite effect of increasing sales rates by improving available information. A comparison of contaminated with cleaned up sites would be necessary to demonstrate this effect definitively. No studies to date have estimated the welfare effect from a change in property transaction rates.

6.3.1.5 Advantages, Limitations, and Recommendations

Property value models offer a useful approach to estimate the various benefits that accrue to owners of properties affected by sites undergoing cleanup and reuse. The experts participating in the 2006 EPA workshop came to the consensus that property value models represent "the best prospect for defensible studies of the social benefits of land cleanup and reuse" (Smith 2007, p. 41).

Workshop participants recommended that future studies employ panel data of individual property transactions and compare traditional hedonic models with quasi-experimental approaches as a means to advance the property value approach. Researchers have also raised the important issue of understanding how property value model estimates relate to WTP for land cleanup. It could prove useful for analysts to clearly identify significant events related to cleanup and reuse along a timeline, and then gather and interpret data accordingly. In tandem with property value analysis, analysts might also want to examine whether cleanup activities affect the rate, not just the price, of property sales to assess whether cleanup activities lead to benefits from improved information. Some additional advantages and limitations, and recommendations are:

Advantages

- Property value models can provide an aggregate estimate of the benefits accruing to property owners located near a contaminated site, including both cleanup and reuse benefits and direct and indirect use benefits.
- If data are readily available, analysts can conduct a property value analysis in a short amount of time.

Limitations

- Benefit estimates might not reflect reductions in health risks if property owners are not well-informed about these risks.
- Property value models do not measure non-use benefits.
- Property value models are only suitable for retrospective analysis.

[44] Jenkins et al. (2006) reviewed several studies that empirically investigated how contamination levels affected property sales and redevelopment.

- Property value models are vulnerable to omitted variable bias, although spatial fixed effects, quasi-experimental methods, and panel data can help address this problem.
- It can be difficult to estimate the benefits of non-marginal changes in land contamination using property value models, particularly the hedonic model.
- Property value models might not capture the benefits associated with quick cleanups not well-reflected in sales transaction data.

Recommendations

- It is important to use real prices or log prices to control for inflation.
- Analysts can easily test a variety of flexible functional forms for property value models.
- Individual housing transaction data within a few miles of the site are preferable to reported housing values and to housing prices or values at more aggregate spatial scales.
- Analysts can compare the demographic and socioeconomic characteristics of residents near sites affected by cleanup and reuse with those of control populations included in the analysis using simple statistical tests to assess the importance of omitted variable bias.
- Analysts should consider whether estimates from capitalization models represent WTP, an upper or lower bound on WTP, or simply the rate of change in property values.
- Data from several different points in time before, during and after the cleanup are useful for examining cleanup and reuse.
- Analysts need information on liability and cleanup costs when using property value models to estimate the on-site benefits of remediation.

Box 6.3 - A Stated Preference Study of Contaminated Site Cleanup in Italy

Alberini et al. (2007) administered questionnaires to a sample of residents of four cities in Italy with serious contaminated site problems. The survey experiment gathered information from respondents about three related issues: WTP for mortality risk reduction, preferences for permanent cleanups, and the effect on WTP of delaying the start time of cleanup.

The authors conjectured that the value of reducing mortality risk from exposure to toxics at contaminated sites might differ from the value of reducing such risks from other exposure routes. The cancers and other diseases that result from exposure at contaminated sites are accompanied by a high degree of dread and the risks are involuntary. As a result, it may be inappropriate to simply transfer estimates of WTP for mortality risk reduction from other contexts.

The survey consisted of conjoint choice questions that elicited respondents' trade-offs between income and risk reduction. Respondents were shown pairs of hypothetical public programs described by five attributes including the annual risk reduction afforded by the program, how soon the risk reductions would be observed, and the cost of the program to the taxpayer.

Responses to the questions resulted in estimates of the value of statistical life (VSL) of €5.6 million for an immediate risk reduction. The authors noted that this was very close to the VSL suggested for use in agency analyses by the then-current U.S. EPA *EA Guidelines* (2010e). However, if the risk reduction occurred 20 years in the future, the VSL was €1.26 million. This result implies a discount rate of about seven percent, which suggests that people do indeed care about permanence, but place a premium on reducing risk in the near term.

6.3.2 Stated Preference Methods

Stated preference (SP) methods involve surveying individuals about their choices in hypothetical situations. Rather than observe individuals' actual behavior in market settings to make inferences about their preferences, economists ask respondents to indicate their WTP for some non-market good in an attempt to "create the missing market" (Carson et al. 2003, p. 258). Surveys present open-ended, dichotomous or multiple choice questions (contingent valuation), or choices between two or more alternatives (conjoint analysis). Economists then analyze these data with a variety of econometric techniques, depending on the type of survey implemented.

Advantages of the SP approach include its flexibility and its applicability to nonuse as well as use values (Smith 2007). The hypothetical nature of questions allows researchers to ask respondents about goods that they would never encounter in a marketplace, or that they would never directly use. Indeed, SP surveys are the only method currently available to researchers concerned with monetization of nonuse values (Boxall et al. 1996). For example, studies on the Exxon Valdez oil spill elicited nonuse values for preventing the release of hazardous substances using contingent valuation (Carson et al. 2003, Desvousges et al. 2010). While nonuse values are not expected to be a major benefit category resulting from cleanup and reuse efforts, SP studies offer the opportunity to test whether they might play a role for certain types of sites or programs.

Flexibility in crafting the survey allows researchers to ask individuals about proposed or future policies. Another advantage of SP surveys is their ability to investigate the impact of timeline and delays on WTP for land cleanup. For example, a survey assessing Italian households' WTP for risk reductions at contaminated sites found that participants would pay substantially less for cleanups occurring far in the future, implying a positive discount rate for reductions in land contamination (Alberini et al. 2007). (See Box 6.3 for further discussion of this study.) SP also minimizes the endogeneity concerns that plague property value studies, since researchers can introduce random variation in the variables of interest across participants as part of the survey design. SP surveys can investigate heterogeneous preferences for site cleanup among demographic groups as well (Patunru et al. 2007).

SP surveys can be combined with risk assessment methods to determine the value that participants place on the risk reductions caused by contaminated site cleanup (Loomis et al. 2009). Such surveys could gather information on individuals' WTP for specific health, ecological or other risk reductions. Alternatively, they could ask about the behaviors participants would undertake to mitigate risks caused by contaminated sites. This information can then be combined with data gathered via risk assessment. Surveys can also gather information about respondents' risk perceptions that could be useful in estimating preferences for site cleanup (Just 2008).

The greatest challenge in using SP methods lies in designing and conducting a survey that produces credible benefits estimates. For example, EPA commissioned a contingent valuation study to estimate nonuse values from ground water cleanup at RCRA sites (McClelland et al. 1992), but a Science Advisory Board panel did not have confidence that the survey respondents understood the commodity they were being asked to value (U.S. EPA 1993).

Critics point to several potential sources of bias that could affect estimates (Boyle 1993, Diamond and Hausman 1994). Sensitivity to scope, hypothetical bias, and consequentiality are of particular importance for SP surveys. Sensitivity to scope concerns how WTP responds to changes in the amount of the good provided in the valuation scenario (Smith and Osborne 1996). If the good is a "normal good," then economic theory implies that WTP should increase with the provision of the good. Hypothetical bias occurs when survey responses systematically differ from what individuals would pay if the transactions were actually to occur (List and Gallet 2001; Murphy et al. 2005). Consequentiality or incentive-compatibility concerns whether respondents believe their responses will influence public policy or otherwise have some impact on products available (Mitchell and Carson 1989; Carson and Groves 2007).

Valuation scenarios should be as realistic and easy-to-understand as possible to obtain truthful responses. Reliability and validity tests can be incorporated into the survey design to help gauge whether the results are likely to be biased. Reliability tests examine whether questions elicit consistent responses over time (e.g., test-retest assessments of responses) or across surveys (e.g., meta-analysis), while validity tests verify that WTP estimates behave in accordance with economic theory (e.g., sensitivity to scope and income). Two types of validity are worth noting. Criterion validity concerns how well SP estimates relate to other measures, such as actual market data, that are considered better indicators of the concept being assessed (e.g., WTP). Convergent validity, in contrast, does not assume the superiority of one measure, but instead examines the degree to which SP estimates are related to other measures as predicted by theory. Section 7.3.2.3 of the *EA Guidelines* (U.S. EPA 2010e), "Considerations in Evaluating Stated Preference Results," describes a number of additional issues for analysts to consider when creating SP surveys or using prior estimates from such surveys in benefit transfer.

Creating and executing a well-designed survey is costly and time-consuming. Several months are typically required to develop, pretest and revise the survey before it is implemented. There is no consensus about the most effective mode for carrying out the survey. In-person interviews, telephone surveys with mail follow-up and national internet panels have different advantages and disadvantages (Mannesto and Loomis 1991, Bell et al. 2011), though all are expensive. Relative to property value analysis with existing sales data, SP studies are often less feasible to implement for benefits analysis given time and funding constraints.

Despite these potential disadvantages, many economists at the 2006 NCEE-LRO workshop noted that SP studies fill a useful role in valuing many types of benefits across many different land programs (Smith 2007).

6.3.2.1 Stated Preference Studies of Property Values

As discussed previously, revealed preference property market data are useful for researchers investigating the benefits of land cleanup because they reflect the tradeoffs that people make between housing prices and local amenities. Some researchers using SP studies to assess land cleanup benefits have also used the scenario of the housing market as a basis for contingent valuation or conjoint choice surveys. Instead of asking respondents whether they would be willing to pay a certain amount of money to implement a public cleanup program or remediate a particular site, these studies solicit participants' hypothetical choices between properties with different prices and other characteristics described by the researcher. Just as in a revealed preference hedonic study, these characteristics can include size, number of bedrooms, school quality, or exposure to a contaminated site nearby. Grounding the SP data with such real-world scenarios can potentially reduce hypothetical bias and can facilitate the assessment of criterion and convergent validity. Both revealed and SP studies grounded in the housing market share a conceptual basis in that they measure the benefits of environmental policies based on the change in local environmental quality that is reflected in housing prices.

SP studies of housing markets typically recruit homeowners in communities with a history of land contamination so that respondents have some experience with contamination and home-buying decisions. For example, Smith and Desvousges (1986) estimated WTP to live farther from hazardous waste landfills among homeowners in suburban Boston, which has many such sites. Chattopadyay et al. (2005) and Patunru et al. (2007) surveyed recent homebuyers in communities near the Waukegan Harbor Superfund remedial site to estimate how much more they would have paid for their homes if the harbor had been partially or fully cleaned.

SP investigations of the housing market have certain advantages that can improve analysts' understanding of the benefits of land cleanup that are reflected in property values. The ability to randomize a treatment across participants allows researchers to avoid biased estimates due to omitted variables correlated with both property values and land contamination. In addition, stated preference studies can be designed to examine large, discrete changes such as those brought about by a major Superfund remedial site cleanup, while traditional hedonic models are suited for examining only marginal WTP. SP surveys also offer the opportunity to test whether the different measures of a land contamination disamenity discussed in Section 6.3.1.1.2 (such as proximity to a contaminated site, level of exposure, or number of sites within a specified area) yield equivalent results. Braden et al. (2006) found some support for the hypothesis that moving farther away from a contaminated site would yield similar net benefits as site remediation. Theoretically SP studies could disentangle the changes in property valuations due to concerns about exposure to risk versus other reasons.

SP studies can fall prey to some of the same difficulties facing revealed preference models in interpreting estimates of increased property values as measures of WTP. For example, studies that survey property developers, real estate agents, or others knowledgeable about the market may successfully solicit the increase in property values attributable to a land cleanup program, but as discussed in Section 6.3.1.2, increases in property values only represent the benefits of site cleanup under certain circumstances (e.g., stability of residents' preferences over time). SP studies focused on housing markets are also unlikely to capture the total benefits of site cleanup if remediation is expected to yield ecological, nonuse or other benefits unlikely to affect property prices. In contrast, SP surveys that are not specific to the housing market can be designed to estimate these values.

6.3.2.2 Combining Stated and Revealed Preference Approaches

Researchers have often viewed revealed and SP methods as substitutes for estimating the benefits of environmental policies. However, recent literature has treated the two types of data as complementary (Whitehead et al. 2008). While revealed preference studies have the advantage of being grounded in real-world choices, SP surveys can gather information about novel policies or scenarios outside the range of current experience. Using RP and SP together is more costly than employing a single approach, but it offers the opportunity to take advantage of the relative strengths of each method. Section 7.3.3 of the *EA Guidelines* reviews some advantages of combining RP and SP data.

Some studies have implemented RP and SP studies of the same site or program in order to check the robustness of the estimates, since convergent findings across different approaches help to increase confidence in the results. For example, Chattopadhyay et al. (2005) used both a conjoint choice survey and a hedonic property model to estimate the value of remediating contaminants at the Waukegan Harbor Superfund site and found the two methods to yield very similar results. Research by Braden et al. (2008a, 2008b) found some divergence in the results from hedonic and SP studies examining remediation of the Sheboygan and Buffalo River Areas of Concern, two different contaminated areas of the Great Lakes. A study of the UST program in Maryland examined the possibility of designing an SP survey to measure the benefits of the program in tandem with a hedonic property value study (Alberini and Guignet 2010, Zabel and Guignet 2010).

Besides simply comparing benefit estimates across the two methods, researchers can pool SP and RP data to jointly estimate parameters that would not be identified by either dataset alone. Phaneuf et al. (2010) combined revealed and SP data in a hedonic model to estimate the value of both marginal and discrete changes in exposure to a contaminated site in Buffalo, New York. In this approach, the researchers used data on actual housing sales to calibrate the value of marginal changes in the baseline model and relied on the SP data to estimate the value of a large-scale cleanup. SP surveys have also been combined with revealed preference data on recreation demand (a valuation method discussed briefly in the next section) to estimate WTP for cleanup of contaminated aquatic sites (Morey and Breffle 2006).

Analysts with the option to employ multiple valuation methods in tandem will help advance understanding of land cleanup benefits, both those that are reflected in market transactions such as housing purchases and those that are not.

6.3.2.3 Advantages, Limitations, and Recommendations

SP methods are a widely-adaptable tool to measure the value of land cleanup and reuse benefits, especially nonuse benefits. However, designing surveys that elicit unbiased estimates of WTP is time consuming and expensive. Analysts can conduct SP and property value studies in tandem for the same site or set of sites to determine how they compare and contrast. Advantages, limitations and recommendations to bear in mind include:

Advantages

- SP surveys can be used to assess all benefit categories, including nonuse and ecological benefits.
- SP surveys minimize omitted variable bias, since researchers can introduce random variation in the survey design.
- SP surveys can be used to evaluate hypothetical policies or activities that have not yet been implemented, including non-marginal changes in land contamination status.
- They offer a complementary approach to property value studies that can lend insight into the reasons behind property value adjustments.
- SP studies can be designed to investigate issues such as timeline, stigma, improved information and risk perceptions that can be difficult to address with revealed preference data.

Limitations

- There are many potential sources of bias that affect SP surveys including sensitivity to scope, hypothetical bias and consequentiality.
- SP studies are time consuming; analysts typically need over a year to design, test and conduct a survey and complete a subsequent analysis. For analysts at federal agencies, the Information Collection Request process required under the Paperwork Reduction Act can add to the length of time required to implement an original survey.
- Conducting focus groups and administering SP surveys is expensive.

Recommendations

- Attention to potential sources of bias and use of realistic and easy to understand scenarios that can be compared with revealed preference data can help obtain truthful and unbiased responses.

- Reliability and validity tests can be incorporated into the survey design to help gauge whether the results are likely to be biased.
- Analysts can implement SP and RP studies in tandem to obtain complementary information and improve the credibility of results.

6.3.3 Other Economic and Non-economic Methods

While property value models and SP methods have received the most attention in the valuation literature for assessing land cleanup and reuse activities to date, other approaches might also be relevant for analyzing benefits. As with the property value and SP methods, these other approaches might or might not rely on data estimated via risk assessments.

6.3.3.1 Other Economic Valuation Methods

Many economic valuation methods besides property value models and SP surveys could be applicable to assessing land cleanup and reuse benefits, depending on the program, site and importance of the different benefit categories. Approaches that have received less attention in assessing land cleanup and reuse benefits include recreation demand, production and cost functions, averting behaviors, and cost of illness.[45] These valuation methods must often be combined with health or ecological risk assessment data to obtain benefit measures, as discussed in Section 6.2. These approaches are covered in detail in Section 7.3.1 of the *EA Guidelines*, "Revealed Preference Methods," so the discussion below is limited to how they might apply to land cleanup.

Recreation demand models can be used to value ecological improvements from land cleanup or reuse that lead to enhanced recreational experiences. This approach values changes in environmental quality by examining tradeoffs travelers make between environmental quality and travel costs. Analysts can use this approach to measure recreational benefits provided they have information on how land cleanup or reuse activities affect environmental amenities important to recreational activities, such as swimming or fishing water quality. For instance, an OSWER study examined the recreational benefits of improved water quality in Biscayne Bay stemming from Superfund remedial actions in South Florida's Homestead Air Reserve Base (Nicholas et al. 2008). Researchers have estimated the impact of contamination from three major Superfund remedial sites on fly fishing in Montana's Clark Fork River Basin using a stock-catch function and recreation demand model (Morey et al. 2002). Other recreation demand studies that may be applicable to land cleanup have examined the losses to anglers from fish consumption advisories targeting polychlorinated biphenyl (PCB) contaminated waters (Jakus et al. 1998, Jakus and Shaw 2003), and the value to hunters of reducing mercury contamination in pheasants (Shulstad and Stoevener 1978).

Analysts can estimate production and cost functions to measure the value of a marginal change in environmental quality by quantifying its effect on the value of producer output or costs. No studies were identified that have applied the approach to measure land cleanup benefits to date, though it could be relevant for measuring ecological and materials benefits. Production and cost functions have been used to examine the value of ecosystem services such as soil erosion control

[45] Production and cost functions, travel costs and averting behaviors, like hedonic analysis and other property value models, are all revealed preference methods for valuation, in contrast to SP surveys. COI is not a revealed preference method, since it does not measure WTP.

provided by agroforestry species (Pattanayak and Mercer 1998) and aquifer recharge from wetlands (Acharya and Barbier 2000). This approach could be applied to land cleanup if production or cost data, measures of the change in land contamination, and information on the change in ecosystem services or ecological or health risks caused by land cleanup are all available.

Averting behavior models examine the costs people incur when taking actions to avoid risks or other negative effects caused by poor environmental quality; for example, the costs associated with acquiring bottled water in order to avoid contaminated public drinking water. Analysts need data on the averting actions taken and their associated costs. The *EA Guidelines* provides a thorough discussion of the use of averting behavior to estimate the benefits of environmental quality changes, and Blomquist (2004) covers the theoretical basis of the model.

COI models are another approach used to tackle health benefits by examining the avoided medical expenses, lost wages, and other costs attributable to health risk reductions. As discussed by the *EA Guidelines*, cost of illness is not equivalent to WTP for several reasons. Medical insurance creates a distortion in the market for health care, driving a wedge between costs incurred by the individual and the value of resources used to treat the illness. COI does not account for averting behaviors or costs undertaken to avoid illness. COI estimates also omit categories of health costs such as pain and suffering. However, because WTP estimates for the value of reduced risks are unavailable for many health outcomes, particularly non-cancer illnesses, COI offers a practical alternative to infer the magnitude of health benefits. Reliable risk assessment information is crucial for generating credible benefit estimates using both averting behavior and COI. Lybarger et al.'s (1998) study of reductions in VOCs in drinking water, discussed in Box 6.1, offers an example of COI applied to land contamination.

6.3.3.2 Non-economic Methods

When credible valuation of benefits is impossible due to data or other barriers, it is still important to discuss benefits in qualitative or quantitative non-monetary terms (U.S. EPA 2006a). For instance, EPA's preliminary Superfund Benefits Analysis provided quantitative indicators of the ground water resources protected by remedial actions, estimating that water quality had improved in 125 aquifers as a result of the program. Other non-monetary indicators that may be relevant to cleanup or reuse efforts include the number of species or organisms affected, the habitat area restored, or the reduction in beach closure days.

Non-economic quantitative approaches may be particularly relevant in the area of ecological benefits. Habitat equivalency analysis (HEA), a tool often used in Natural Resource Damage Assessments, offers a framework for assessing the ecological impacts of remediation and restoration alternatives in terms of habitat area or other biophysical metrics. Dunford et al. (2004) review HEA's appropriate uses and its limitations. HEA can only be used as a proxy for economic value under limited circumstances (U.S. EPA 2009c). A Science Advisory Board report on the benefits, costs and impacts of the RCRA and UST programs recommended quantitative landscape analysis as another approach to assess the effects of RCRA cleanups on ecosystem services (U.S. EPA 2002a). This type of analysis could supplement an assessment of the number of avoided contamination events with GIS data on indicators of scarcity of the ecosystem services affected, demand for those services (like proximity to population centers and recreational areas), and complements or infrastructure needed to access the services.

It is worth noting that Natural Resource Damages (NRDs) arrived at through court settlements are not an appropriate tool for measuring the benefits of land cleanup (U.S. EPA 2006a). NRDs attempt to measure not only the damages due to the loss of resources, but also the costs of replacing or restoring habitats (U.S. EPA 2007a). Replacement costs are not an appropriate measure of cleanup benefits, and the ecological services component of damages is not constant across assessments. Final figures are typically arrived at by negotiation or court order and can be quite different from the results of an economic assessment of benefits, as illustrated by studies of the Exxon Valdez oil spill (Carson et al. 2003, Desvousges et al. 2010).

6.3.3.3 Calculating Agglomeration and Greenfield-saving Benefits

Estimating the benefits from preserving open space that results from urban brownfield redevelopment is a challenging task that lacks a well-developed methodology. As discussed in Section 6.1.5.4, brownfield redevelopment that preserves greenfields can avoid the need to build new infrastructure and can save ecological or amenity benefits that would otherwise be lost.

Infrastructure cost savings are a challenge to estimate and are likely to vary significantly across locations. Analysts face the challenge of speculating about a hypothetical alternative development site and the infrastructure spending necessary for it. In addition, analysts must estimate what infrastructure spending would be required to accommodate reuse at the brownfield location. Thus, while infrastructure cost savings can be important to an individual case, values seem likely to vary significantly depending on specific circumstances so generalizing these benefits should be avoided.

A consensus about the appropriate way to calculate the amount of land and identify sites that would have been used under alternative development scenarios has not yet emerged. For example, Deason et al.'s (2001) study calculated a ratio of greenfield acres preserved relative to brownfield acres developed, known as a greenfield-brownfield offset ratio, based on urban and suburban municipalities' regulations on lot size, setbacks, parking requirements, and other density restrictions. Using data from 48 brownfield redevelopment projects in six metropolitan areas, they estimated that each acre of redeveloped brownfield land would prevent more than an acre of greenfield development on average.

A different approach to calculating greenfield-saving benefits emphasizes the different pollution levels expected by developing a brownfield as opposed to a hypothetical preserved greenfield. For example, in an assessment of the Atlantic Steel brownfield development project, EPA relied on regional transportation and air pollution models to estimate different vehicle miles traveled and emissions levels at the developed brownfield compared to a variety of hypothetical greenfields (U.S. EPA 1999). EPA's Office of Brownfields and Land Revitalization and Office of Sustainable Communities recently released a study that focuses on reuse projects in five urban areas. Results suggest that brownfield reuse leads to lower air pollution and storm water runoff relative to hypothetical greenfield developments. There was a range of impacts across cities due to regional variation in development and travel patterns (U.S. EPA 2011b).

Existing studies have not considered whether land use regulations could have changed in suburban areas in response to development, nor have they investigated local market conditions as an indication of whether the brownfield developments could have plausibly located in outlying areas (Wernstedt 2004). It is also worth noting that offset ratios could change if brownfield reuse is widespread enough to induce changes in local real estate prices and zoning laws, another factor not accounted for by existing studies. It is even possible that brownfield development could spur additional development due to agglomeration effects.

These complexities suggest that calculating a greenfield-brownfield offset ratio is a challenging empirical issue for analysts tackling greenfield-related benefits. Analysts might be able to estimate the difference in expected development footprints between central and outlying areas using data on local land prices. The development "footprint" is also likely to vary across and within municipalities depending on local property values and population densities. Examining the density of recent developments in the vicinity of the identified greenfield and brownfield sites might be a useful sensitivity check for offset estimates to ensure that they are consistent with local development patterns. Because greenfield-brownfield offset ratios are highly localized and subject to change, analysts should avoid applying national or dated greeenfield-brownfield offset ratios or using average values in the presence of large outliers when assessing possible greenfield preservation benefits. In addition, analysts calculating their own offset ratios should clearly document all assumptions behind the calculations.

6.3.3.4 Advantages, Limitations, and Recommendations

Analysts should be aware of other economic and non-economic approaches to assessing land cleanup and reuse benefits besides property value models and SP surveys. Production and cost functions, recreation demand models, averting behaviors, and COIs could prove useful, provided that risk assessment data or other measures of the changes in environmental quality being valued by these methods are available. Non-monetary indicators or non-economic approaches might also be of interest, particularly in the realm of ecological benefits, which economists often struggle to monetize.

Advantages

- A variety of economic models could potentially contribute to analysts' understanding of land cleanup and reuse benefits.
- Non-monetary approaches offer the opportunity to provide quantitative indicators of benefits, particularly ecological outcomes, not adequately captured by current economic methods.

Limitations

- Data requirement for implementing these approaches can be daunting, particularly since good health or ecological risk assessment information is often necessary.
- No consensus exists as to the best method to calculate brownfield-greenfield offset ratios, and these ratios are highly localized and subject to change.

Recommendations

- It is important to evaluate and discuss significant non-quantifiable and non-monetizable benefits associated with land cleanup and reuse.
- Damage values arrived at through court settlements are not an appropriate tool for measuring land cleanup benefits.
- Analysts should avoid national or dated estimates of brownfield-greenfield offset ratios.

6.3.4 Benefit Transfer

The discussion of the different methods used for benefits analysis has primarily focused on proper estimation of models and interpretation of the results. This section turns to the application of these results in policy analysis through the technique of benefit transfer. When analyzing the impacts of a policy or program, there are instances when funding, time or other constraints prohibit an original study of environmental valuation. In this case, it may still be possible to obtain benefit estimates through benefit transfer. This process involves the application of non-market benefit estimates from one study (the "study case") to another situation (the "policy case"). It allows the application of past results to forward-looking policy analysis.

Benefit transfer is a relatively recent practice in the field of environmental valuation—only gaining prominence in the last 20 years—although the wider field of economics has engaged in the practice of using past welfare estimates to value current policies in other contexts, such as the estimation of elasticities (Boyle et al. 2010).[46] The credibility of estimates derived using benefit transfer rests on several important factors discussed in this section.

EPA's *EA Guidelines* (2010e) outlines the main process for conducting a benefit transfer, which is composed of the following steps: (1) describe the policy case, (2) select the study cases, (3) transfer values, and (4) report the results. During the first two steps of the process, there are several important considerations. First, the definition of the environmental commodity being valued should be similar in the policy and study cases. This includes geographic considerations relevant for land contamination such as local ground water conditions and topography. Second, the baseline and the nature and extent of the environmental changes should be similar. For example, ideally the baseline land use and the sources and types of contaminants would be similar in the study and policy cases. Third, the characteristics of the affected populations should be similar, which includes demographic and cultural aspects. All three considerations are important for benefit transfer, although they do not guarantee a valid or accurate transfer. Also, as discussed below, it may be possible to still conduct a useful transfer even if all three conditions are not fully met.

These issues are particularly relevant when estimating land cleanup and reuse benefits. For example, the RCRA/UST benefits proposal suggested the use of past hedonic results from Superfund sites in a benefit transfer (U.S. EPA 2000a, b), but a Science Advisory Board panel took issue with the proposal due to differences in contamination and risk between NPL sites and RCRA/UST sites (U.S. EPA 2002a). The Science Advisory Board also expressed reservations about using three existing contingent-valuation ground water studies to value health effects (Edwards 1988; McClelland et al. 1992; Powell, Allee, and McLintock 1994). None of the studies considered benzene, the primary pollutant of interest, and in two of them, respondents were told that there would be no health risks.

There are two main types of benefit transfer: the unit value transfer and the function transfer. With a unit value transfer, a range or point estimate of value (such as mean or median WTP) from the study case is used to value the policy case. This approach is clearly limited by the quality of the original study, and depending on one estimate, amplifies the need for similarity of the study and policy sites.

[46] Environmental benefit transfer first received detailed consideration in a 1992 special issue of *Water Resources Research* (Vol. 28, No.3). Multiple studies have since tackled the subject, with the current state of the literature summarized in recent special issues of *Ecological Economics* (Wilson and Hoehn 2006) and the *American Journal of Agricultural Economics* (Ready 2009), as well as Boyle et al. (2009; 2010). Several recent papers have also evaluated benefit transfer using environmental applications (Downing and Ozuna, 1996; Kirchhoff et al., 1997; Brouwer and Spaninks, 1999; Piper and Martin, 2001; Morrison et al., 2002). Although there have been multiple advances in the field, there is still no consensus on the procedure that yields the lowest transfer error.

A benefit function transfer is a more flexible approach in which an equation is transferred from the study site to the policy site, allowing the benefit value to vary over relevant characteristics. This allows the transfer to be better tailored to the specifics of the policy site. There are three main types of function transfers: the preference function transfer, meta-analysis, and preference calibration. Preference function transfer and preference calibration are theoretically consistent ways to transfer benefits (Ready 2009). In a preference function transfer, the estimates from a prior study are used to transfer a utility or demand function to the policy site (Boyle et al. 2010).[47] While this approach is an improvement on the unit value transfer, it is still reliant on the results of a single previous study.

Meta-analysis represents a way to use estimates from multiple studies to conduct a benefit transfer. In this approach, value estimates from several studies are regressed on the characteristics of those studies, such as geographic location or sample size. Those regression results are used to control for some of the characteristics of the policy site during the benefit transfer. This can improve the transfer by introducing variation in site or attribute characteristics (Ready 2009) and controlling for selection effects (Rosenberger and Johnston 2009). Several recent EPA water rules, such as the Florida Numeric Nutrient Rule, have used this approach to obtain values.[48] The draft Superfund Benefits Analysis included a preliminary meta-analysis that combined values from several past hedonic studies to value the entire Superfund program (U.S. EPA 2005c). A Science Advisory Board panel found multiple problems with the transfer (U.S. EPA 2006a). In particular, the hedonic studies relied on the price-distance gradient to value marginal changes, which may not transfer well to a policy that aims to convert areas from contaminated to remediated (a non-marginal change). Additionally, most of the hedonic studies were done in densely populated areas, which may not transfer well to rural Superfund sites.[49]

A difficulty with meta-analysis is that the underlying studies it transfers from may use different measures of value, such as Marshallian or Hicksian.[50] Although one solution to this problem is to be selective with the underlying studies, an alternative is preference calibration. In this approach, the analyst specifies a utility or transfer function, which is then calibrated with the results of several previous studies (Smith et al. 2002). Preference calibration ensures that the transfer is consistent with economic theory and illuminates the assumptions of the utility function. However, preference calibration may be sensitive to the underlying studies and specifications used (Van Houtven and Poulos 2009). Also, while areas like water and air quality have multiple studies to transfer from (Johnston et al. 2005), results on land cleanup and reuse are more limited in the available literature. This can be a problem for both meta-analysis and preference calibration.

Although the *EA Guidelines* do not explicitly endorse a particular approach to benefit transfer, one of the few areas of agreement in the literature is that function transfers are preferred to unit value transfers (Boyle et al. 2010). OMB's *Circular A-4* contains a section on benefit transfer

[47] For a recent example of this type of transfer in the area of forest recreation, see Zanderson et al. (2007).
[48] Federal Register Vol. 75, No. 233, December 6, 2010, FRL-9228-7.
[49] Revisions to the hedonics portion of the draft Superfund Benefits Analysis evolved into a description of the literature rather than an attempt to place monetized values on the benefits of the Superfund Program. It presented an assessment of some of the challenges in applying results from the existing hedonic residential property value literature to estimate the benefits of the Superfund Program as a whole (U.S. EPA 2008).
[50] These concepts are further discussed in the *EA Guidelines.*

that supports the same conclusion. Although there is no agreement on the preferable function transfer to use, a recent paper by Boyle et al. (2009) provides a set of necessary conditions for all function transfers, which will yield a consistent value estimate at the policy site. These results show that in function transfers, the similarity between study and policy sites can be relaxed by properly specifying and calibrating the transfer function.

In the context of land cleanup and reuse, there can be additional concerns with benefit transfer. Sites and their associated risks can be very heterogeneous, so that the results of one study may not transfer to another. There can be considerable heterogeneity in the number, type and mix of contaminants over sites. Studies of Superfund remedial sites such as Hamilton and Viscusi (1999) and Kiel and Williams (2007) have documented considerable variation in estimated cleanup benefits. Hamilton and Viscusi found the cost per averted cancer case to vary from less than $20,000 to over $1 billion over a sample of 150 sites considered nationally representative based on past use, region and type of contamination. Another concern is the spatial extent of benefits, a topic which has only received minor attention in the literature (Smith 1993, Smith 2011). Different types of risk can have large heterogeneity in their spatial impact, which should translate into differences in benefit extent.

The variability across sites suggests that analysts should be careful to select existing studies that are as relevant as possible to the policy case and to document the criteria for study selection. Analysts undertaking such a project are advised to proceed with caution and justify the similarities between the policy and study cases in terms of contamination level and type, site size and category of use, notoriety, community demographic characteristics, the timeframe covered by the data (panel or cross-sectional), and other factors relevant to the specific case.

6.4 SUMMARY

Land cleanup and reuse efforts have the potential to generate multiple benefits for society—from the sources often considered in environmental policy analysis (like health risk reductions) to additional categories unique to the land context (particularly improved land productivity). Estimating the value of these benefits has proven challenging, even for individual sites. Efforts to assess the aggregate effects of cleanup programs to date have fallen short. New techniques, an ever-increasing supply of data, and careful identification of the issues involved provide analysts with an opportunity to improve upon existing studies and obtain more accurate estimates of the full range of benefits stemming from land cleanup and reuse efforts.

The primary valuation methods in analysts' toolkits are property value analysis and SP surveys. Additional methods are also available, such as analysis of averting behaviors and COIs. Estimates of realized risk reductions that help analysts determine the biophysical effects of land cleanup programs can also be used with valuation methods to develop monetary estimates of benefits. Estimates derived from different valuation methods can be compared or used in concert with one another, particularly when the cleanup activity touches on multiple benefit categories.

7 Cost Estimation

This chapter turns to measurement of the costs of land cleanup and reuse efforts. Analysts may find that these activities present unique analytical challenges with regard to cost estimation, some of which are not covered in the *EA Guidelines* (U.S. EPA 2010e). Land cleanup is distinct from many environmental regulatory programs because much of the cleanup cost burden is comprised of fixed costs. Many "typical" air or water regulations require facilities to reduce ongoing production-related emissions. In contrast, land cleanup programs often require remediation of hazardous materials left over from earlier uses that are not related to the current use, except by geography. As will be demonstrated, cost estimation is different in this case.

This chapter offers definitions and suggestions for modeling costs and describes special circumstances in which a relatively simplified analysis is appropriate. It opens with a discussion of social cost in the land cleanup and reuse context. Section 7.2 covers direct costs, emphasizing issues unique to land cleanup and reuse, and describes potential data sources and approaches for estimating direct costs. Section 7.3 considers costs in partial and general equilibrium frameworks. Additional non-market costs are described in Section 7.4, and Section 7.5 provides a chapter summary.

7.1 Estimating Costs in the Land Cleanup and Reuse Context

The *EA Guidelines* states that there is a single, comprehensive cost measure appropriate for BCA called "social cost." Social cost is defined as "the total burden a regulation will impose on the economy," both in the present and future—in other words, the opportunity cost of all resources used (U.S. EPA 2010e, p. 8-1). When resources are devoted to cleaning up and redeveloping land, they cannot be used to produce other goods and services that people value. In addition to labor and capital spent containing, treating and removing contaminants, social cost might include downtime for businesses or other facilities on or near contaminated sites. Social cost is a comprehensive measure, and in addition to market effects, it includes the welfare cost of any negative externalities that might result from land cleanup activities. Social cost is the appropriate measure for analysts to use in a comparison with social benefits.

Although every land cleanup project is unique, analysts may find that cost estimation follows a general pattern. The first task is to estimate the direct costs associated with the project. The easiest to compute and likely the most important components of direct costs will include the value of labor and materials used to assess, clean up and redevelop a site. Direct costs will also include the regulatory costs incurred by federal, state and local governments in administering land cleanup programs. Depending on the scope of the cleanup and reuse initiative, analysts may also be required to use a partial equilibrium model to consider additional social costs including social welfare losses resulting from changes in market prices. If they are expected to be important, analysts should also account for indirect costs that are driven by behavioral responses of affected businesses, households or other groups in related markets with a general equilibrium model. Finally, analysts should consider any non-market factors such as ecological disturbance.

7.2 Direct Costs

Direct costs are expenditures incurred in assessing, removing, containing, treating, transporting and/or disposing of pollutants, plus any program administration costs. In this discussion, direct costs are analogous to compliance costs incurred to meet an emissions standard, but can also include expenditures associated with site redevelopment. It is important that any redevelopment costs be incorporated into this measure of direct costs when considering benefit estimates that include both reuse and remediation. This will ensure that the cost estimates are comparable to the benefit estimates.

7.2.1 Assessment and Cleanup Costs

In many cases, the majority of direct costs are incurred in the assessment and cleanup of contaminants. They can be one-time capital costs such as soil incineration and asbestos removal. They can also be ongoing maintenance and operation of a cleanup technology, such as ground water treatment. A joint document by EPA and the U.S. Army Corps of Engineers provides guidance for estimating costs associated with alternative remedial actions (U.S. EPA 2000d).[51] Remedial and removal program activities like assessment and cleanup comprised 75 percent of annual EPA Superfund expenditures from 2006 to 2010.

Box 7.1 - EPA Expenditures on the Superfund Emergency Response and Removal Program in Region 3

As part of a study on the Superfund Emergency Response and Removal Program in the Mid-Atlantic region, Jenkins et al. (2011) gathered data on EPA expenditures at 83 sites in Region 3 where cleanups were completed between 2001 and 2006. These data reflect EPA funds spent on assessment, cleanup, payroll and travel. The authors collected this information from EPA's internal Superfund accounting system.

The median level of EPA spending at sites in the dataset was $338,000 and ranged between $0 and $52 million (2008 dollars). The variation in expenses across sites reflects a great diversity in contaminated media and cleanup approaches, which included removing contained contaminants and debris, as well as addressing contaminated soil, ground water, surface water, air, and chemical spills. The highest-cost removal action, something of an outlier in the sample, was EPA's response to the widely publicized anthrax bioterrorism incident on Capitol Hill in 2001. Median expenditures were higher at sites with soil and ground water contamination and contained contaminants than at sites with air or surface water contamination or risk of fire or explosion. Not surprisingly, costs to EPA were generally higher at sites with multiple removal actions compared to sites hosting only one removal action.

The authors noted that EPA expenditures do not represent the social cost or even the full direct cost of removal activities because they do not include costs to potentially responsible parties, state agencies, or other federal agencies, nor potential ecological or health impacts from cleanup actions. Potentially responsible parties led and financed removal actions at 21 of the sites, while EPA either fully or partially financed activities at the remaining 62 sites. (EPA incurred at least some expenses at most sites, sometimes just for travel and payroll in its supervisory role.)

Cleanup costs vary considerably from site to site, so it is preferable to track them individually instead of applying average cost estimates. Cleanup efforts target different contaminants, contaminant mixes, media, and exposure routes. They employ diverse technologies to address these different circumstances. Different controls and monitoring equipment are needed for varying lengths of time to minimize risk. Different initial risk levels and cleanup standards also create varying levels of risk reduction across sites. Hamilton and Viscusi (1999; see Box 6.1 in Chapter 6) found that 20 percent of properties accounted for 47 percent of capital, maintenance and operations expenditures in their sample of 150 NPL sites. Another study found that information on site type, EPA hazard score, remediation technology, and quantity of contaminated soil helped predict cleanup costs for NPL sites, but these factors together explained less than 10 percent of the variation in cost estimates (Barth and McNichols 1994).

[51] Another useful resource for EPA analysts trying to estimate cleanup costs at a specific Superfund site is the Superfund Cost Estimating Toolbox developed by the Superfund Program. Its purpose is to inform independent government cost estimates for assessing contractor bids for remedial action work. It is accessible only to EPA staff with a password. Contact Superfund.web@epa.gov for more information.

To take one example of how different remediation technologies impose different costs, consider energy use. The cost of electricity varies across regions, sites, and remediation technologies. In general, the Northeast and California face higher electricity prices, and the Midwestern states have lower prices, compared to the South and Northwest. Analysts should use local electricity prices when calculating energy costs, as national or regional averages can be misleading. It is also important to sum the total electricity costs over the lifetime of the project with appropriate discounting.[52] For instance, thermal desorbtion, a technique that heats soil to remove contaminants, is energy intensive but requires only a few months of operation. Conversely, ground water pump-and-treat, a common remediation method used at Superfund sites (U.S. EPA 2002b), has moderate annual electricity costs, but the multiyear timeframe of most pump-and-treat projects can mean that high energy costs accrue over the course of cleanup activities.

It might be tempting to consider wages paid to labor engaged in cleanup efforts as benefits and indeed, workers who accept these jobs view them as beneficial; however, these expenditures comprise part of direct costs for cleanup, just as expenses on equipment and materials do. As already discussed in Chapter 3, labor costs should be measured as the opportunity cost of the workers' time. This cost is typically assumed to equal the wage rate, but in certain situations, such as projects that result in net reductions in unemployment, the true opportunity cost of labor could be lower than the wage rate (Haveman and Farrow 2011). Employment impacts could comprise part of an economic impact analysis, as discussed in Chapter 8.

The permanence of the cleanup approach is another determinant of direct costs at Superfund sites (Gupta, Van Houtven, and Cropper 1996). Containing pollutants presents a less permanent and typically less costly fix than treatment and removal. For communities dependent on contaminated ground water, the least expensive course of action might be to apply a cap on the soil and find alternative drinking water sources. More permanent and more expensive remedies involve soil incineration and long-term ground water treatment. Congressional directive favors permanent treatment of NPL sites, despite the higher costs (Hamilton and Viscusi 1999). For RCRA and Brownfield sites, the remediation approach chosen often depends on plans for reuse of the property (U.S. EPA 2000c, U.S. EPA 2005a).

Institutional and engineering controls that restrict future land use to protect human health might supplement cleanup depending on the remediation approach. Institutional controls include zoning rules, monitoring, and provisions in a property's deed, while engineering controls are physical barriers like caps or fences. Such ongoing activities should be taken into account in direct cost estimates. Pendergrass and Probst (2005) have discussed how to conceptualize and estimate the costs associated with institutional controls.

Direct costs also include the costs of assessing a site to determine the level of contamination and the remediation approach. The EPA Brownfields Program awards grants specifically for site assessment.

7.2.2 Program Administration Costs

Resources expended on administering, monitoring, and enforcing programs that remediate properties and encourage their reuse represent program administration costs. These costs are typically funded by taxpayer dollars, whether at federal, state or local levels. Some costs, such as

[52] Chapter 6 in EPA's *EA Guidelines* (2010e) provides further discussion on discounting future costs.

identifying and negotiating with responsible parties for Superfund sites, are specific to an individual cleanup, while others, like the salaries of staff who administer national, state and local cleanup programs, are not. Management and administrative costs like facilities, operations and security made up 11 percent of annual Superfund expenditures from 2006 to 2010, while 14 percent of expenditures covered enforcement activities like identification of responsible parties, negotiation and litigation. Responsible parties might also face administration costs, particularly legal expenditures, which can be substantial relative to their cleanup expenditures (Acton and Dixon 1992).

7.2.3 Redevelopment Costs

When land cleanup fosters the redevelopment of a property for a new use, it can generate additional social benefits. It is also important to account for the social cost of reuse. Redeveloping a parcel requires additional capital and labor resources on top of those used to remediate contaminants. Redevelopment costs are relatively straightforward to conceptualize and quantify; they often involve expenses on materials, equipment and personnel. Property owners or developers bear much of these costs, though public funding is sometimes provided by federal, state, and municipal-level programs, particularly for projects that meet other social goals like providing employment opportunities for the local population or developing affordable housing or open space. For example, brownfields grants are sometimes complemented by Economic Development Assistance grants administered by the Department of Commerce. No studies were identified that estimated the comprehensive costs of reuse associated with Superfund or other cleanup programs.

7.2.4 Data for Estimating Direct Costs

Obtaining site-level data is ideal for determining remediation costs, but can pose a challenge. Information on government-funded cleanup expenditures is typically publicly available. However, no centralized authority tracks cost data for remediated sites. Data sources and quality can vary considerably depending on the program or activity under study. For NPL sites, ex ante cost estimates are publicly available in RODs, and EPA site-specific documents can provide useful information, as in the cost estimates constructed by Hamilton and Viscusi (1999). A proposed analysis of the UST program suggested using state UST trust fund data, which include information on reimbursements for UST releases and number of incidents, to estimate direct cleanup costs (U.S. EPA 2000a). The appendix summarizes several other data sources by cleanup program.

When site-level data are unavailable, as could be the case for cleanup expenditures paid by private firms or for sites that have not yet been remediated, engineering models describing the remediation technologies can be used to estimate direct costs. The U.S. Army Corps of Engineers, in conjunction with EPA, developed a detailed guide to aid analysts in developing cost estimates for remediation activities (U.S. EPA 2000d). The guide aims its discussion at Superfund sites, but its examples and discussion of remediation costs and data sources are relevant to a more general land cleanup scenario. For direct redevelopment costs, various construction cost estimators are available to provide estimates of the cost of building different types of structures. Data from RSMeans[53] have been used to quantify construction costs in other EPA actions.

Analysts may also make use of data collected by the U.S. Census Bureau Pollution Abatement Cost and Expenditures (PACE) survey, which contains establishment level data for both operating costs and capital expenditures related to site cleanup for the manufacturing sector.[54] The survey was administered from 1973 to 1994 (except in 1987), and then again in 1999 and 2005. Prior to 1991, cleanup expenditures are contained within the overall hazardous waste management cost estimates, though in subsequent years cleanup expenditures were reported separately. A proposed analysis of the RCRA subtitle C program planned to use PACE survey data for cost estimation (U.S. EPA 2000b). Text Box 8.2 in the *EA Guidelines* provides more detail on the history and potential uses of PACE data.

7.2.5 Direct Costs as a Measure of the Social Cost of Land Cleanup

Land cleanup differs from many other environmental regulations because it involves assessment and cleanup of past rather than ongoing contamination. The following analysis provides a theoretical rationale for the use of direct cost as a measure of the social cost of cleanup and reuse in many circumstances. Readers less interested in this background theory section may wish to skip ahead to Section 7.3. This discussion assumes that private responsible parties are held liable for the fixed cost of remediation. When the government foots the cleanup bill instead, then the behavior of the firm is not the target of analysis.

Land cleanup costs may be categorized as unavoidable fixed costs, as opposed to variable costs, since the expenditures are related to past rather than current production.[55] From the analyst's perspective, what matters is that the total expenditure is determined by the stock of contamination rather than the quantity of goods or services produced at present or in the future. The timeframe of remediation does not affect this classification of cleanup costs as fixed costs. For cases where the cleanup may take several years (as in the case of ground water treatment) the unavoidable nature of the expenditures allows one to simply consider the fixed costs as the expected present value of any future outlays.

Farmer (1997) considered the role of environmental mandates, including those that impose upfront unavoidable fixed costs, on firm behavior within the basic competitive framework. The analysis suggests that since these expenditures are sunk costs, they should have no effect on the firm's production decision, as long as the firm remains in the market.[56] This finding suggests that direct compliance costs may provide an adequate measure of social costs for the case of site remediation. It is important to note that this result will only hold under the assumptions that prices, unit costs and discount rates remain constant. These conditions are typically met for

[53] RSMeans' CostWorks, an online construction cost estimating tool, is available at https://www.meanscostworks.com/.
[54] The 1999 PACE survey also includes data from the mining and electricity sectors.
[55] Strict liability provisions, such as those enacted in CERCLA, suggest that cleanup costs should always be treated as unavoidable.
[56] Similarly, sunk costs of redevelopment are expected to have no effect on the behavior of the firm once it has decided to locate at the reused site. Reuse might also entail variable costs, but these costs will be reflected in the post-reuse value of the land, which is equal to the discounted present value of net earnings.

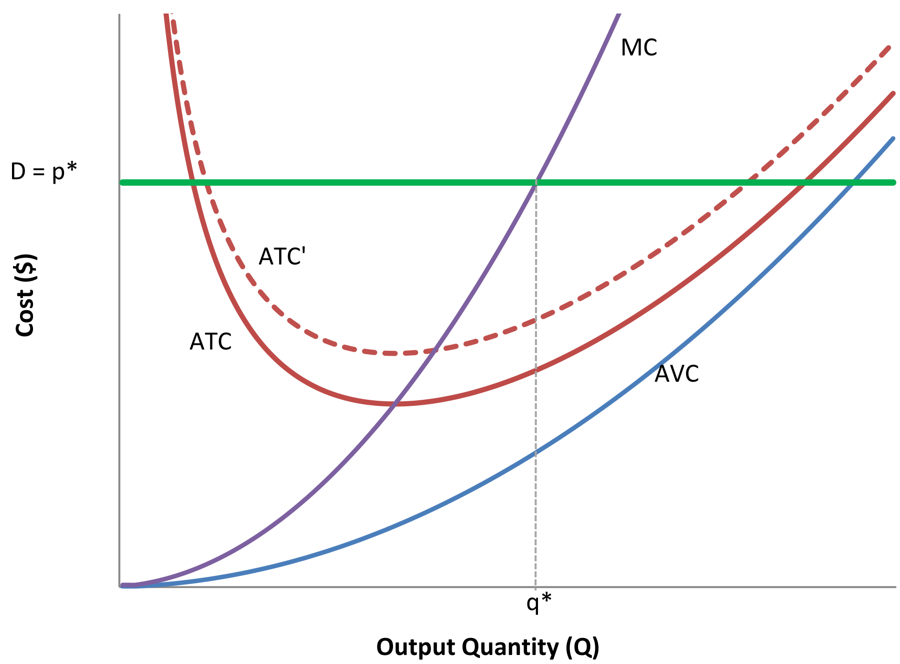
remediation projects since the cleanup will not necessarily impact an entire industry, as would be the case with regulations governing pollution flows stemming from current production processes.

A stylized example is presented in Figure 7.1 to further illustrate the point. The figure depicts the short-run cost curves of a small firm operating in a competitive market so that it takes the market price as a given (i.e., the demand curve is perfectly elastic). Average variable costs are denoted by AVC, while average total costs, the sum of average fixed costs and average variable costs, are denoted by ATC. The supply curve traces the marginal cost (MC) curve above AVC. The profit-maximizing output level is where the supply curve crosses the price, or demand, curve (D = p*).

The additional unavoidable fixed costs associated with remediation will result in an increase in the total fixed costs associated with production, leading to an increase in total cost. This is represented by the upward shift in ATC to ATC'. Since the remediation expenditures do not influence the variable cost structure, there will be no adjustment in the MC curve, and thus, q*, the profit maximizing output level, remains the same. This situation differs from other types of pollution control programs that raise marginal costs, typically leading to a reduction in the quantity of output produced as long as demand is at least somewhat elastic.

This illustration does not suggest that land cleanup imposes zero costs on private firms. The sunk costs divert resources away from the production of other goods that people value. The opportunity cost of the resources used to clean up a site is reflected in the prices of those resources and is accounted for as part of direct costs.

Figure 7.1 - Short-Run Cost Curves for a Small Competitive Firm with a Fixed Cost Increase



In Figure 7.1, cleanup costs are reflected in lower profits, where profits are defined as the excess of market price over average total cost. In this example, there is no "cost pass-through" to consumers because the small competitive firm has no market power to raise its price. All costs are reflected by lower profits. This outcome suggests that in the particular situation of a small firm facing a fixed cost of cleanup, it is acceptable to use direct costs as a measure of the social cost of remediation because there are no partial equilibrium price impacts in the industry, although it might be necessary to account for program administration costs as well as the types of non-market costs discussed in Section 7.4.

The assumptions of a short-run time frame and perfectly elastic demand are not necessary to obtain the result that direct costs represent social costs. In a long-run competitive equilibrium, in which there are no economic profits, firms with average total costs above prices would be forced to exit the industry. The fixed remediation cost would be capitalized into the value of the contaminated land and still not affect the opportunity cost of the productive activity (Smith 2011). Although the firm would remain liable for this cost per legislative and regulatory requirements, it is possible that production could simply shift to other firms located elsewhere, with no effect on the total market supply of the good.

In the case where many firms in an industry are affected and production at contaminated sites changes due to remediation activities, a partial or general equilibrium analysis may be required to estimate additional components of social cost. In these cases, direct cost estimates alone might not sufficiently represent social cost; however, they are an important input into partial and general equilibrium models that consider additional social welfare changes.

7.3 Land Cleanup Costs in a Partial or General Equilibrium Framework

While the previous section suggests that direct costs will provide an adequate measure of social cost in most situations, exceptions are possible. In certain cases, remediation activities may result in social costs that differ from direct costs as a result of market changes—for instance, if many firms within an industry are affected, leading to a contraction in the total market supply of a good. As discussed in Chapter 5, partial or general equilibrium models may be required to estimate these costs in full.

A partial equilibrium model provides a useful framework to estimate social costs when the effects of the cleanup are limited to a single or limited number of markets. For example, a reduction in market supply due to firm closures could lead to a welfare loss on the part of consumers who face higher prices and purchase less of the good than they did previously.

Chapter 5 notes that if the land cleanup and reuse activity under study triggers significant price changes in many sectors of the economy, a general equilibrium rather than a partial equilibrium approach is preferable. It is possible that federal land cleanup programs or regional land remediation and redevelopment projects could substantially affect markets other than the one directly regulated. For instance, federal regulation of UST cleanups affected gas stations nationwide and might have had far-reaching effects because gasoline is so widely used in the economy.

General equilibrium analysis would also be useful to understand how cleanup financing (whether public, private or a combination of the two) affects the distribution of costs through the economy. As mentioned, the analysis in the preceding section assumed that private responsible parties pay the fixed cost of remediation. However, if EPA or a state agency pays for cleanup, then the social cost includes direct costs and any deadweight losses from taxation—in other words, the social cost of raising public funds.[57] For this case a general equilibrium framework is required to estimate the full social cost of the land cleanup activity.

7.4 Non-market Costs

Direct expenditures by governments and responsible parties and associated behavioral impacts are not the only cost categories associated with land cleanup and reuse. Temporary human health risks and ecological damages could also contribute to the social cost of land cleanup activities. The sub-sections below discuss these additional aspects of social cost.

7.4.1 Health Risks

Land cleanup technologies can involve waste incineration or excavation of contaminants that could lead to temporary harmful airborne emissions (ATSDR 1992). For example, Superfund sites undergoing remediation for lead contamination can release lead-enriched dust into the air. Cleanup activities can displace pollutants that affect human health through other pathways as well, such as soil excavation that contaminates ground or surface water.

EPA regulates hazardous waste incineration under RCRA to protect human health, and the Superfund program requires safety plans to address protection of nearby residents. For instance, lead risks are monitored using stations that track concentrations around a site. One careful simulation of potential exposure to airborne lead by nearby children during remedial activities at an NPL site in West Dallas concluded that there was no significant long term or acute risk (Khoury and Diamond 2003). Still, if there is a possibility that emissions will exceed legal limits during cleanup operations and pose some risk to surrounding populations, this social cost should be considered.

In addition to heightening health risks in the community, cleanup workers can experience increased risks on-the-job. Superfund limits risks with mandatory safety plans that describe precautions and necessary equipment for site personnel (U.S. EPA 1995). Wages paid as part of cleanup costs reflect any remaining risks, and analysts need not calculate them separately unless they wish to examine distributional issues in addition to total direct costs.[58]

7.4.2 Ecological Damages

Even as cleanup efforts remove toxins from the environment, it is possible that they could disturb fragile ecosystems or damage vulnerable habitats and populations. Activities such as excavating wetlands and incinerating soil can pose hazards to vegetation and animal life (Efroymson, Nicolette, and Suter 2004). EPA seeks to avoid harming ecosystems through its remediation efforts more than it would under the baseline of no action (OSWER directive 9285.7-28P) and offers guidance on “greener cleanups” that minimize energy use, water use, and other environmental impacts.[59] Still, ecological damage is possible and is a potential social cost of cleanup efforts.

[57] The *EA Guidelines* Section 8.1.2 provides further discussion and examples regarding the concept of deadweight loss from taxation.
[58] Wage hedonic models are a common approach used to value this type of risk. Chapter 7 of the *EA Guidelines* gives more background on this method.
[59] http://www.epa.gov/oswer/greencleanups/index.html

As discussed in Section 6.1.3, valuation of ecosystem services remains difficult due to a lack of data and methods. When monetization is not possible, qualitative or quantitative non-monetary approaches should be considered, such as those discussed in Section 6.3.3.2.

7.5 SUMMARY

Estimating the costs of land cleanup and reuse activities presents several unique challenges. This chapter defines social cost and presents direct costs, as well as partial equilibrium and general equilibrium frameworks for assessing the costs of land cleanup, and to a lesser extent, land reuse. It discusses methods and data for measuring direct costs of cleanup, a necessary step under all frameworks. Total direct costs of cleanup and reuse include the costs of cleanup, program administration and redevelopment.

Theoretical results suggest that for cases in which cleanup costs are unavoidable and fixed and do not affect many firms, industry output and prices will remain unchanged. If this situation holds, and if there are no other non-market costs such as temporarily heightened health or ecological risks, the analyst can report the total direct cost estimate in a comparison with benefits, or alone as a measure of social cost.

When firms raise prices or cut production as a result of land cleanup activities in one or a few directly affected markets, partial equilibrium models can be used to estimate the associated social cost. General equilibrium models, which are ideal for examining economy-wide costs, could be applicable to large or ambitious land cleanup and reuse projects if they affect the competitiveness of an industry or a geographic region. If expected to be significant, costs stemming from health risks and ecological damages can be estimated using property value models, SP, recreation demand and other methods.[60] While most benefit-cost analyses quantify direct cleanup costs, few encompass the full social cost of land cleanup and reuse efforts—a crucial distinction highlighted here to ensure that costs are conceptually comparable with benefits.

[60] The reader is referred back to Section 6.3 for detailed discussion of non-market valuation methods.

8 Economic Impact Analysis

The previous two chapters of this *Handbook* focused on measures of the social benefits and costs of land cleanup and reuse. This chapter covers EIA and equity assessment, focusing on measures that give insight into the reallocation of resources resulting from cleanup and reuse. As discussed in Chapter 3, EIA examines a variety of metrics to understand how resources affected by remediating and reusing land are reallocated. Rather than summing effects to derive a single impact number, EIA allows analysts to focus on transfers and a variety of non-monetary indicators like employment rates. Frequently, policymakers are interested in impacts that affect specific regions, industries or demographic groups. The results of EIA could be particularly useful to city planners, economic development offices, and community groups, among others.

Chapter 9 of EPA's *EA Guidelines* (U.S. EPA 2010e) covers EIA. The reader is referred to this discussion for an extensive look at methods for determining the changes in prices, output, employment, tax revenues, and other potential effects of environmental regulation. Land remediation can also further environmental justice goals by revitalizing land in blighted, economically depressed neighborhoods where past contamination might have depressed property values. Indeed, economic development has become an explicit goal of EPA cleanup initiatives, particularly the Brownfields Program, making EIA an important tool for evaluating their success.

This chapter focuses on EIA measures and methods most applicable to land cleanup and reuse.[61] Reviewed first are the different types of impacts typically associated with cleanup and reuse, including employment, business openings and output changes, government impacts, and environmental justice. The second section examines several descriptive and predictive approaches analysts can use to assess the effects of land cleanup and redevelopment on industries, sectors, regions and communities. The discussion draws heavily on several resources, including a workshop on the community impacts of reuse (Probst and Wernstedt 2004); a study on the impacts of land revitalization in Baltimore, Maryland (Creason 2008); two draft guidebooks on land reuse impacts that were never finalized (U.S. EPA 1997, U.S. EPA 2005b); three white papers covering brownfield redevelopment and employment (Howland 2007), land reuse impacts (Wernsted 2004) and gentrification (Banzhaf and McCormick 2007); and external peer review comments provided by Bartik (Smith 2011).

8.1 Considerations for Assessing Land Cleanup and Reuse Impacts

Before turning to the specific types of impacts often of interest to analysts assessing land cleanup and reuse, this section briefly discusses some considerations common across several impact categories. First is the issue of measuring impacts relative to a baseline that reflects economic activity under a business-as-usual scenario without the cleanup or reuse. For example, if a remediated parcel becomes the site of a new manufacturing plant, analysts must consider where the plant would have located absent cleanup activity and the resulting implications for output and employment in order to determine the economic impacts attributable to cleanup and reuse.

[61] Many economic impacts of interest are associated with reuse more than cleanup, like permanent jobs and new business revenue. In practice, it is difficult to disentangle cleanup and reuse impacts, particularly since reuse is made possible by cleanup and in many cases the planned reuse is a determinant of the cleanup approach. In this chapter, cleanup and reuse impacts are not separated.

Defining the geographic boundaries of the analysis is also crucial. Cleanup and reuse activities can have economic effects beyond what occurs directly at the site that might be considered as part of local, regional or national economic impact analysis. It is important to consider the net impact over the entire geographic region of interest. Analysts must define the area of interest depending on the objectives of the study and the audience.

In general, economic impacts from cleanup and reuse will tend to be positive near the site but negative farther afield, as resources flow to the remediated area and its surroundings from other locations that might have seen investment in the baseline. Thus, the smaller the scale of analysis, the more likely that impacts will appear to be positive. In a larger scale analysis, transfers from other localities that entail no net change in the larger economy should be subtracted out, yielding smaller impact estimates. At the same time, a more expansive analysis could lead to a larger multiplier effect, as more effects throughout the economy are included in the impact measure.

For local or regional impact analyses, a key issue is whether land redevelopment results in an increase in "export-base" industries. Export-base sectors are those that attract dollars from outside the local economy, as opposed to industries that provide goods and services that are primarily consumed within the region. For example, a new manufacturing facility producing goods sold outside of the region will generally have a larger impact on the regional economy than a new residential development.

If reuse does not lead to an expansion in export-base sectors, then there is less likely to be a long term net increase in resources flowing into the region via the redeveloped site. In this case, output or employment created at the site will most likely displace other local output or employment by lowering sales to local residents elsewhere. In contrast, export-base work may generate additional local employment opportunities at suppliers to the export-base industries, and the additional worker income can generate increased consumer demand. The magnitude of these local or regional effects depends on the relative labor intensity of the production processes of affected sectors and general equilibrium changes in local wages and prices. Models currently available to estimate regional effects, such as input-output or dynamic forecasting models (discussed further below), often provide only crude approximations of actual effects. Few assessments of the accuracy of such models that compared their predictions to ex-post evaluations of economic effects were located. At least one, Kasimati (2003), compared ex ante input-output studies of employment gains from the Olympic Games to an ex post assessment and concluded there was possible overestimation by the former.

For national level analysis of cleanup and reuse programs, the net impact over all sub-regions should be considered. Net national economic impacts would only be positive if the reuse is in a location or industry where investment is expected to have above average marginal economic impacts (such as an area with a particularly low opportunity cost of labor or with excess infrastructure). This holds true for a variety of impact categories discussed in the next section, including employment, output and tax revenues. The issue of export-base industries is less critical at the national level, since a large portion of the resources drawn to a community by these industries have shifted from elsewhere in the economy.[62]

[62] However, there is the possibility that an export-base industry will draw resources into the nation from international sources.

Another issue relevant for impact assessment is the source of financing used to pay for the cleanup and reuse—whether private sector; federal, state, or local government; or some combination of these. Remediation and redevelopment expenditures represent social costs, as discussed in Chapter 7, but the cost distribution can be of interest for economic impact analysis in the region of interest or the national economy as a whole. For example, when a private firm pays for cleanup, these expenses act as a tax on capital, which will typically have different impacts on output and employment from the case where government tax revenues are used. In addition, the impacts of private sector funding and federal deficit financing could vary depending on whether the economy is in recession or at full employment. Input-output and dynamic forecasting models that are sometimes used for predicting economic impacts capture only limited effects associated with cleanup and reuse expenditures in the private sector; for example, they omit those associated with changes in tax rates or deficits.

8.2 Land Cleanup and Reuse Impact Categories

Many economic impacts could be of interest to analysts examining land cleanup and reuse activities. The most relevant will depend on the purpose of the study and the scale of the analysis, whether site, regional or national level. The impacts most frequently measured include employment and income, business openings or closings and outputs, government impacts, household and residential impacts, and effects on different socio-demographic groups.

8.2.1 Employment and Income

Increasing employment opportunities is an oft-cited goal of land cleanup and reuse efforts. Such opportunities can fall under several different categories. Positions can include temporary construction work during remediation and redevelopment, permanent jobs at new businesses created after reuse, or even preexisting jobs at firms that would have closed without cleanup. Positions filled by unemployed and/or local residents might be of particular interest.

Howland (2007) reviewed several case studies on brownfield redevelopment employment effects. She found that most studies counted permanent on-site jobs, but failed to report other job categories or related impacts, including:

- Whether jobs are new, or simply transferred across space
- Temporary remediation and construction jobs
- Share of positions filled by unemployed people
- Job quality (e.g., degree of upward mobility)
- Job stability
- Indirect employment impacts in the site's host community
- Other social and economic impacts in the host community

As mentioned in Section 8.1, whether jobs are new to the economy as a whole or balanced out by reductions in employment at other locations is an important issue raised by EIA that depends in part on the scale of the analysis. However, even if reuse does not generate measurable "new" jobs, gross job creation in areas with high unemployment or low income is an impact that is often of interest.[63] Examining unemployment rates and educational attainment in the study area could

[63] As discussed in Chapter 3, new jobs do not create social benefits unless they put un- or underemployed people to work on balance or are viewed from the perspective of a region receiving transfers from an entity outside the bounds

help analysts assess whether redevelopment could advance environmental justice or other distributional goals. Limited econometric evidence indicates that in-migrants take many of the jobs created by development projects, though existing residents also fill some of the new positions, and local unemployment rates decrease overall (Bartik 1991). Projects with the greatest success in filling positions with local workers are those that involve the local community in redevelopment plans and match jobs to the skills of local residents (Howland 2007). In addition, job training programs and financial incentives for businesses to hire locals can improve the prospects of new employment opportunities for underemployed local populations, particularly in low-income or minority communities that may have historically faced environmental justice issues.

While analysts conducting an EIA might seek to quantify the net change in employment throughout the geographic area of concern as a result of the remediation and redevelopment project, specific quantitative estimates should be regarded with caution. As mentioned, readily available input-output or dynamic forecasting models (such as REMI and IMPLAN) give rough approximations of expected effects and are only appropriate in a narrow set of cases. These models hold technology and production processes constant and thus characterize only short-term effects. They are also not appropriate when policies are expected to result in shifts in trade or changes in government revenues (see Section 8.3.2). Analysts should take care to provide sensitivity analysis of any partial quantification. In addition, they should augment quantification with a robust qualitative discussion of the limitations of the model used and of additional sources of employment impacts not estimated. In cases where impacts cannot be quantified and there are competing positive and negative effects on employment, analysts should note that the direction of the overall net change is ambiguous.

Temporary remediation and construction positions are not always considered in EIAs because their transitory character means that they will typically have smaller impacts on the economy. There is also a greater chance that the workers might not be permanent residents of the study region. However, cleanup jobs could be of particular interest to certain programs. For instance, Environmental Workforce Development and Job Training Grants fund training of environmental technicians living in brownfields communities, so remediation jobs might be a relevant impact indicator for this and similar initiatives.

The type of redevelopment can also affect the number and type of jobs. Commercial and industrial land uses, particularly those in export-base industries, often employ more permanent workers than residential development. Sites converted to residential use typically have higher cleanup standards than those slated for commercial or industrial use, employing more temporary remediation workers, but setting up a potential tradeoff between cleanup stringency and long-term economic development (Howland 2007).

An increase in labor demand in a particular region due to a cleanup and reuse project could also raise both wage rates and labor productivity levels as workers gain more skills and experience as a result of the employment opportunities (Bartik 2005). Again, it is important to consider whether in the long run this effect might net out to zero at the geographic scale of concern, given that a foregone increase in wages and labor productivity elsewhere in the economy is expected.

of the analysis. Currently under development, an appendix to the *EA Guidelines* will discuss how to account for putting unemployed people to work in BCA.

EIAs of employment impacts will prove most informative to policymakers, local organizations, and others planning and evaluating redevelopment projects if they address the issues discussed in Section 8.1 of measuring impacts relative to a business-as-usual baseline at an appropriate geographic scale. It is also important to clearly document the timeframe over which jobs are expected to last. Analysts should take care when reporting the number of jobs associated with a reuse over the project's expected lifetime (Probst and Wernstedt 2004). For example, if a redevelopment project generates 200 jobs expected to last an average of 10 years each, this should be reported as such or as 2,000 job-years but not as 2,000 jobs. When the economy is in recession and marked by persistent high rates of unemployment, analysts may wish to highlight the number of jobs, even temporary ones, that are expected to be filled right away.

8.2.2 Business Openings/Closings and Output

While employment is often the most prominent impact of land reuse, several other measures are often of interest to cleanup agencies, local officials or the public. The number and size of new businesses established and existing businesses protected or displaced is one indicator of economic performance at the reused site. Output or revenue of these businesses is another common measure. Like employment impacts discussed above, it is important to consider the net impact over the entire geographic region of interest relative to baseline conditions and not just impacts directly at the site itself.

Agglomeration—increases in productivity due to geographically clustered development, particularly in urban centers—is another potential effect of reuse that could interest local planners and analysts. Previous research on land reuse suggests that beneficial economic impacts of reuse are more likely to occur when several sites in the same locality are redeveloped; minimal evidence supports the hypothesis that cleaning up and converting a small, single site to a new use can spur revitalization throughout the local economy (Howland 2007).

While recent empirical work has documented positive agglomeration effects (Greenstone et al. 2010), there is little evidence about how marginal agglomeration effects vary by type of land use (e.g., industrial or commercial), location or specific industry. This information is critical for assessing the long-term net effects of cleanup and reuse on economic activity over the entire geographic region of interest because analysts must consider not only positive agglomeration in the vicinity of the cleanup and reuse, but also foregone agglomeration in other relevant areas. Unless there is reason to believe that these marginal impacts are different, for a national level analysis it may be reasonable to assume that such effects cancel out, with no net benefits to the economy. Section 6.1.5.2 also discusses agglomeration.

8.2.3 Taxes and Government Impacts

Land reuse can affect the fiscal viability of local and state governments. Redevelopment can boost local property taxes if land cleanup and reuse result in higher property values. Likewise, changes in the number of new businesses, employment rates and incremental consumer spending can affect state income tax and local and state sales tax revenue. These potential tax revenues could be important factors for local or regional officials deciding whether to invest in reuse efforts. Even if tax revenues represent transfers from municipalities where they otherwise would have been collected, they could advance social equity goals if they accrue to local governments in low-income communities with stressed tax bases. Bartik and Erickcek (2010) provide an example of how to calculate fiscal effects using state-level tax effects estimated by Bruce et al.

(2006). Section 9.2.4 of the *EA Guidelines* (U.S. EPA 2010e) on "Detailing Impacts on Governments and Not-for-Profit Organizations" mentions several additional indicators of government fiscal health beyond taxes that could be included in an EIA.

Governments might also incur expenditures to fund or encourage cleanup and redevelopment activities that should be balanced against increased tax revenues. Incentives offered by local governments to support redevelopment might include tax increment financing, enterprise zones or infrastructure improvements. Because their budgets are limited, governments could face a tradeoff between funding cleanup at the most hazardous sites and investing in reuse of less contaminated sites that might hold greater potential for development (Howland 2007).

For national level analysis, comparing the gap between marginal fiscal benefits (e.g., tax revenues) and costs (e.g., infrastructure expansion) in the community hosting the redeveloped site to the same gap at alternative development sites would be necessary to infer a net effect. For example, a net effect might depend on underutilized infrastructure at the redeveloped site relative to alternative sites. It is important to avoid double counting both fiscal benefits and any infrastructure savings associated with greenfield preservation discussed in Section 6.1.5.4.

The amount of private investment leveraged for redevelopment is another frequently reported impact measure (Wernstedt 2004). Local officials or public agencies might wish to know how much private financing was spent in conjunction with public investments in reuse. If economic impacts are used to calculate cost-effectiveness measures such as the cost per permanent new or transferred job, it is important to include private as well as public expenditures, or to carefully report that impacts are being expressed in terms of public investments only (Probst and Wernstedt 2004).

8.2.4 Household and Residential Impacts

Successful land reuse efforts are often intended to have positive impacts on nearby residents, which could range from decreased health risk to lower crime rates.[64] Improvements in environmental and other amenities are reflected in higher housing prices and can be estimated using a variety of property value models, as discussed in Section 6.3.1. It is important to note that changes in property values are only a valid measure of social benefits under certain conditions, such as preferences for land contamination remaining stable over time (Kuminoff and Pope 2010), though they could be important to homeowners and local governments even when this condition is not met. Thus capitalization approaches to property value analysis could be relevant for EIA even when the results are not equivalent to WTP for cleanup.

Formerly contaminated sites could themselves be reused as residential developments, increasing the local housing stock. New housing developments could also be built off-site in response to increased economic activity stemming from reuse. The number, price and type (e.g., single family, townhouse, or condominium) of new housing units and proportion of affordable

[64] While it is possible that certain types of land use could have adverse impacts for residents including increased pollution, careful land use planning can avoid negative outcomes. The National Academy of Public Administration (2003) has highlighted the importance of land use planning and zoning for communities affected by environmental justice issues.

dwellings serve as indicators of local housing impacts. Other impacts important to local residents could be captured by equity assessment, discussed below.

8.2.5 Equity Assessment and Environmental Justice

Executive Order 12898 directs federal agencies to consider environmental justice and address adverse environmental effects of regulations on low-income and minority populations.[65] Equity is an important consideration for land cleanup and reuse efforts, which strive to reverse a legacy of contamination that, evidence suggests, could be distributed unequally across income and ethnic groups (Greenstone and Gallagher 2008, Ringquist 2005). EPA's Brownfields Program in particular has addressed equity concerns by providing grants to distressed communities for site assessment and cleanup.

An equity assessment or environmental justice analysis focuses on the impacts of environmental regulation on disproportionately affected groups, including children, the elderly, low-income populations, minorities and tribal communities.[66] Typically, it evaluates the health effects or risk reductions experienced by the groups of concern. However, other impacts such as employment, income, rents, traffic patterns and food consumption may also be relevant. Assessing whether there are adverse effects is important, but in addition it is important to identify whether or not existing disparities are exacerbated or ameliorated by the policy. An equity assessment of land cleanup and reuse activities might focus in particular on outcomes for existing residents of the host community, such as health risks, employment, income, rents and property values, and relocation patterns.

Land reuse could promote environmental justice for disadvantaged local residents by improving job and housing prospects. Alternately, higher property values associated with gentrification (discussed below) could harm vulnerable residents by boosting rents or property taxes. While land cleanup and community revitalization might in many cases go hand-in-hand, in other instances, less contaminated sites might have greater commercial potential than more contaminated sites located in distressed neighborhoods. It could be more difficult to redevelop sites in economically depressed neighborhoods where opportunities for high rates of return may be viewed as limited, as opposed to high-demand urban centers where land is scarce (Howland 2007). Policies to encourage redevelopment in blighted neighborhoods, such as Enterprise Zones, could help offset such difficulties. The Small Business Administration's Historically Underutilized Business Zone Program is one effort specifically targeted to communities affected by environmental justice issues.

Local groups could experience other costs as a result of remediation and redevelopment, such as potential new risk from the treatment or relocation of freshly uncovered contaminants. There may be short periods during remediation when risks are increased relative to baseline, such as from waste incineration or soil excavation (ATSDR 1992). While social cost estimation captures these types of impacts in aggregate, an equity assessment highlights how they will be distributed across different groups.

[65] Executive Order on Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (http://www.epa.gov/compliance/ej/resources/policy/exec_order_12898.pdf).
[66] The *EA Guidelines* includes a placeholder chapter for environmental justice analysis, as the Agency is currently in the process of developing guidance on this topic.

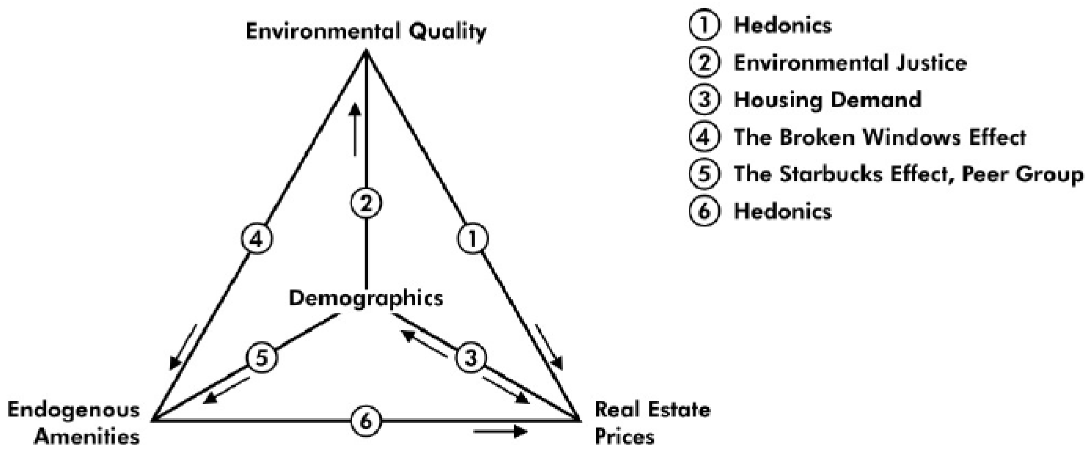
8.2.5.1 Environmental Gentrification

Directing cleanup efforts towards poor neighborhoods with the purpose of benefiting local residents can lead to unintended outcomes. If cleanup leads to increased property values, the result can be an influx of new residents that have higher socioeconomic status than the residents they replace. Such changes in neighborhood character as a result of cleanup are often referred to as environmental gentrification. Gentrifying neighborhoods share a number of features—besides changing resident socioeconomic status, they are characterized by rising property values and rents, new construction or renovation, and a change in the types of local commercial establishments to cater to new residents (Sieg et al. 2004, Banzhaf and McCormick 2007).

Figure 8.1 illustrates several hallmarks of gentrification and the linkages between them. Improvements in environmental quality such as land cleanup could motivate demographic shifts, which could in turn cause real estate prices to increase. Other responses to improved environmental quality might include higher quality commercial establishments, schools and other endogenous amenities. Or an improvement in endogenous amenities might occur indirectly through the change in demographics, an impact sometimes called the "Starbucks effect" (O'Sullivan 2005). A different line of causation might occur between environmental quality and amenities through the "broken windows effect" (e.g., Kelling and Coles 1996) in which decay from brownfields, for example, can possibly exacerbate crime.

Property value analysis (discussed in Section 6.3.1) could be useful for examining some of these effects. However, as discussed previously, gentrification and associated market and non-market feedback effects illustrated in Figure 8.1 also complicate the interpretation of the results from property value models used for benefits analysis. This is because the change in property values cannot be interpreted as WTP for the improvement in neighborhood amenities when the preferences of the population change over the course of the study period.

Figure 8.1 - The Four Sides of Environmental Demography



Source: Banzhaf and McCormick (2007)

Environmental gentrification is a concern to analysts examining equity and social justice because it could indicate that local residents, instead of benefiting from environmental improvements, are losing out. Residents living in communities that host contaminated sites sometimes face severe budget constraints. They may confront the difficult choice of placing a higher priority on low-cost housing than on the environment. Cleaning up contamination could increase housing costs by more than their WTP as wealthier households bid up property values.[67] Low-income neighborhoods often consist disproportionately of renters, who do not stand to benefit from improved housing values. Increased property values typically lead to increased rent, which could unwittingly "push" renters to seek housing elsewhere. The beneficial impacts of reuse could be distributed regressively, because property owners tend to have higher incomes than tenants. Another negative impact of gentrification might be experienced by resident owners who are "driven out" by higher property taxes or a changed set of neighborhood amenities (Banzhaf 2008).

Analysts have empirically investigated environmental gentrification by examining changes in neighborhood demographic variables resulting from changes in environmental quality. Banzhaf and Walsh (2008) found increases in population density and income in response to lower air pollution in California (and decreases in density from higher pollution), consistent with a pattern of gentrification. Cameron and McConnaha (2006) found some evidence of migration behavior by examining demographic and mobility indicators near four Superfund sites, but the effects were not consistent across sites or demographic groups. Vigdor (2008) highlighted the importance of conditions within the affected housing market suggesting that community composition is more likely to change in response to cleanup when housing markets are tight rather than slack.

However, demonstrating that gentrification has occurred does not necessarily prove that the local population has become worse off in response to land cleanup and reuse. If many residents own their homes, they can sell their properties at increased prices and move to new residences with a preferred mix of attributes. If households move frequently, then changing neighborhood amenities might have little effect on already-high turnover rates.

The National Environmental Justice Advisory Council (2006) examined unintended impacts of successful brownfields projects. The study considered the impacts of cleanup and redevelopment activities at five locations across the country addressed by the Brownfields, Superfund, or Base Realignment and Closure Programs. The report concluded that environmental gentrification is a concern, but suggested that EPA involvement, meaningful community involvement, and public outreach could reduce the chances for such unintended impacts of land cleanup and redevelopment.

8.3 Methods for Impact Analysis

Design of an appropriate and informative EIA depends on the program or policy being analyzed and the geographic scale of interest. Some of the simpler descriptive methods discussed below in Section 8.3.1 might be sufficient for single-site or small, locality-specific analyses, or for studies that do not need to predict future outcomes for decision making purposes. However, Probst and Wernstedt have suggested that "once a study purports to describe improvements beyond the truly local, more rigorous methods and quality control are needed" (2004, p. 7). Some of these more rigorous approaches are described in Section 8.3.2.

Some of the same data and methods used for estimating social benefits and costs could be helpful for EIA, and if both analyses are conducted for a program or site, consistency between these

[67] It is important to note that embedded within WTP is ability to pay.

analyses is recommended whenever possible. For instance, as discussed in Chapter 7 of this *Handbook*, compliance cost data and models can be used to determine the engineering costs associated with remediation and redevelopment projects. While these are often aggregated to determine total compliance costs, cost estimates for individual businesses could reveal the relative burdens placed on different companies and industries.

Table 8.1 lists several regional economic assessment tools, distinguishing between descriptive and predictive methods. These approaches have been used to investigate changes in employment, output, taxes, expenditures and demographic trends. This section proceeds by discussing the descriptive and predictive families of tools.

Table 8.1 - Regional Economic Assessment Tools

	Descriptive	Predictive
Location quotients	✓	
Economic base theory	✓	
Shift-share analysis	✓	
Input-output models		✓
Dynamic forecasting models		✓
Other econometric models		✓

Adapted from Creason (2008)

8.3.1 Descriptive Methods

Analysts can use several approaches to gather and analyze basic data for characterizing local economic conditions. Such descriptive measures can help indicate the types of economic impacts and equity considerations that might result from cleanup and reuse activities.

8.3.1.1 Location Quotients, Economic Base Theory and Shift-Share Analysis

Analysts can calculate several relatively simple indicators to describe regional or local economic conditions. A location quotient is the ratio of the local or regional share of employment provided by a particular sector relative to the national share. This figure highlights the industries that are more or less prevalent in the region's economy than they are nationwide.

Economic base theory is a regional analysis tool that examines the composition of local industries to assess growth potential. As discussed in Section 8.1, export-base industries (often manufacturing) depend on demand outside of the region, while non-export-base firms (often retail and service companies) meet demand locally. Base theory suggests that the export-base sector drives local economic growth by bringing income into the area. Export-base industries can typically be identified as those with higher location quotients, indicating that their output exceeds local demand.

Shift-share analysis examines how different industries have changed in importance in a region over time. It helps identify the respective contributions to economic growth of national trends, regional competitiveness, and the change in regional industry composition. Creason (2008) presented the formulas for these measures and calculated them for a case in Baltimore, Maryland (see Box 8.1).

8.3.1.2 Data Sources for Descriptive Analysis

One approach to obtain site-level data on employment during construction and reuse is to interview project managers and employers about the number of full-time equivalent workers and the types of positions they hold (U.S. EPA 2005b). Interviews can also furnish information about redevelopment expenditures and new business output. This strategy has the potential to yield detailed information for a single site, but it might be impractical for assessing community- or program-wide impacts of redevelopment across several sites. In addition, analysts should consider whether employers' prospective estimates of employment, output and other impacts accurately reflect final outcomes.

Employment, output, tax revenue and other data might also be available from grant or loan applications or other documents prepared for agencies that fund cleanup and redevelopment activities. Such information might be tracked by program databases like EPA's Assessment, Cleanup and Redevelopment Exchange System (ACRES) or state-level databases (Wernstedt 2004). EPA's Superfund Redevelopment Database, referred to as SURE, houses information from a variety of sources about reuse of non-federal NPL sites. Published information such as company annual reports and websites might also report employment and revenue information for new businesses on- and off-site.

A practical alternative to interviewing managers, examining site-specific documents, or accessing program databases is to use information on the size, industry and location of redeveloped sites in concert with statistics on average employment and output per area to calculate a variety of impact indicators (U.S. EPA 2005b, Creason 2008). The Department of Energy offers information on the average number of employees per square foot in different industries and regions. Even if this approach yields minimal information on the quality and types of jobs, it could still give rough estimates of the magnitude of the employment effects resulting from reuse.

Other basic calculations can be undertaken to determine impacts like income from newly established jobs and increases in property, sales and income tax receipts. Interviews with project managers and employers might again be a source for this data. Information on average salaries by industry and region (e.g., from the Bureau of Labor Statistics) can help furnish income estimates. Local, state and federal tax rates can be applied to the information on salaries, property size and business earnings to estimate government revenues.

Analysts might also be able to gather information on crime rates, property values, number of residents and demographic characteristics before and after cleanup and/or reuse in the neighborhoods surrounding the target site(s). Information useful for equity assessments, like household income, poverty rates, unemployment rates and ethnic composition is available from the Census Bureau. Caution should be taken to not assume that any changes in these and other measures were caused solely or in part by cleanup or reuse activities without further data analysis to establish causality (such as by using quasi-experimental approaches). Table 8.2 offers a non-exhaustive list of impacts and readily available data sources for EIA.

Table 8.2 - Potential Data Sources for Economic Impact Assessment

Impact Measure	Data Source
Employment, sales, income, and other industry data	Various sources including: • U.S. Census Bureau, Economic Census: http://www.census.gov/econ/census02/ • Securities and Exchange Commission Filings and Forms, EDGAR System Database: http://www.sec.gov/edgar.shtml • Standard & Poor's: http://www.standardandpoors.com • Dun & Bradstreet Information Services: http://www.dnb.com/us/ • Trade publications and associations
Employment Income	• Bureau of Labor Statistics, Quarterly Census of Employment and Wages: http://www.bls.gov/cew/home.htm
Employees per square feet data by industry or region (to inform employment estimates)	• Department of Energy, Commercial Buildings Energy Consumption Survey, Table B-1: http://www.eia.doe.gov/emeu/cbecs/contents.html
Expenditures associate with new or transferred jobs	• U.S. Department of Commerce, Bureau of Economic Analysis: http://www.bea.gov/national/Index.htm
Host community demographics (race, ethnicity, age, income, education)	• U.S. Census Bureau: http://www.census.gov
Annual poverty thresholds	• U.S. Census Bureau, Current Population Reports, Series P-60 on Income and Poverty: http://www.census.gov/prod/www/abs/income.html
Host community housing characteristics	• U.S. Census Bureau, American Housing Survey: http://www.census.gov/hhes/www/housing/ahs/ahs.html • U.S. Census Bureau, American FactFinder: http://factfinder.census.gov/servlet/ACSSAFFHousing?_sse=on&_submenuId=housing_0
Income, property, and sales tax revenues	• State and local government offices. Many websites can be accessed via: http://www.netronline.com/public_records.htm
State and local government finances	• U.S. Census Bureau, Federal, State & Local Governments: http://www.census.gov/govs/

Sources: U.S. EPA (2010e), U.S. EPA (1997), U.S. EPA (2005b), Creason (2008)

For many studies, routine data gathering with no formal analysis comprises the bulk of the work undertaken for an EIA (Wernstedt 2004). While gathering data can provide some useful information to interested parties, these exercises alone are rarely sufficient to determine the extent to which impacts associated with site redevelopment represent net increases in the economy or transfers from other localities, or whether the reuse could have occurred on another site. Neither can they always establish whether the gains can be attributed to the reuse activity or might have occurred anyway under baseline conditions. Finally, they give little indication of the off-site impacts associated with reuse. These data can, however, be used as inputs into more sophisticated descriptive calculations, as well as predictive models that attempt to identify distinctions between transfers and net increases, on-site and off-site outcomes, and causality and concurrent trends.

8.3.1.3 Advantages, Limitations and Recommendations

Several descriptive measures can be calculated with relative ease to characterize economic impacts associated with land cleanup and reuse. Some of these measures can serve as inputs to the predictive analyses discussed below. Advantages and limitations of these measures and recommendations for implementation include:

Advantages

- Relatively simple calculations can shed light on trends important for contextualizing reuse.
- These measures are most likely to be useful for analysis of a single or a few sites.

Limitations

- Prospective estimates of employment, output and other impacts may not accurately reflect final outcomes.
- These methods cannot separate out net from gross changes or compare cleanup and reuse outcomes to a baseline counterfactual scenario without redevelopment to determine whether economic trends are a result of cleanup and reuse activities or other contemporaneous factors.

Recommendations

- Several data sources offer publicly available information useful for calculating impacts.

8.3.2 Predictive Methods

There are several predictive tools that have been used to estimate the potential effects of site reuse. When applied appropriately, these approaches can allow analysts to compare economic activity with redevelopment to a hypothetical baseline in which sites are not cleaned up and redeveloped. However, the analyst should use caution when applying these approaches, as many predictive models are only useful under a limited set of circumstances. Methods for regional EIA include input-output models and dynamic forecasting models, as well as other econometric models that can provide insights on impacts and equity. Descriptive and predictive methods are not mutually exclusive; in fact, predictive models often require some of the same data used for descriptive calculations. Advantages and limitations of these approaches are discussed below.

8.3.2.1 Input-Output Models

Input-output analysis uses information on on-site employment or revenue to calculate the total employment and output impacts associated with cleanup and reuse. The typical input-output model assumes that the production of each included good is governed by a unique linear production function with fixed coefficients (i.e., a Leontief production function). These coefficients represent how much of a particular input is required in the production of the final output, therefore defining the linkage between industries. Input-output models are static, do not include prices, and assume the supply of all inputs is inexhaustible. Thus, while they demonstrate how changes in the economic activity of one entity (e.g., a business, household or industry) ripple through the economy in the immediate term, they do not capture the opportunity costs of using resources.

Input-output models are highly disaggregated and fairly easy-to-use, both appealing attributes, but they assume an infinite supply of resources and do not model a wide variety of adjustments that are expected to occur over time, such as changes in production processes, technology or trade patterns. This suggests that input-output models are rarely appropriate to analyze national-level policies, which could lead to a reallocation of resources throughout the economy, causing firms and consumers to substitute away or toward more expensive or less costly inputs and goods. Input-output models would miss these potentially important substitutions.

Input-output models could be useful to analyze near-term effects of land reuse activities within a single region when the activities are expected to be small compared to the regional economy so that they produce little or no price effects. This should be kept in mind when choosing between partial and general equilibrium models. The latter might not contain sufficient detail to capture the local or regional effects of interest.

Even for regional analyses, however, a serious limitation of input-output models is that they tend to overestimate impacts. They typically include exogenous multipliers that magnify direct effects on output and employment based on the assumption that all new economic activity will recirculate within the regional economy. Input-output models tend to ignore displacement of workers or resources that might occur outside the region under analysis. Finally, as already mentioned, they do not include changes in local prices and wages due to the shock induced by the cleanup and reuse activities. Price and wage changes would drive economic demand towards less-expensive inputs and goods, tending to offset some of the project's regional stimulus. This concern about overestimating regional impacts could be particularly relevant when reuse leads to expansion of an export-base industry that increases the flow of money into the region from elsewhere. One paper was located that compared employment predictions made by input-output models to an ex post analysis of employment effects from hosting the Olympic Games (Kasimati 2003). The comparison suggested that input-output models overestimated effects.

Two commonly used input-output models are the Bureau of Economic Analysis' Regional Input-Output Modeling System (RIMS II; available at http://www.bea.gov/regional/rims/index.cfm) and the Minnesota IMPLAN Group, Inc.'s IMPLAN model. Creason (2008) used IMPLAN as one approach to estimate the impacts of redeveloping several sites in Baltimore, Maryland as discussed in Box 8.1.

8.3.2.2 Dynamic Forecasting Models

Dynamic forecasting models (also called input-output econometric models) combine input-output multipliers with econometric models of the economy to predict impacts across regions and groups. Rather than simple multiplier values, dynamic forecasting models contain basic equations describing firm and consumer behavioral responses that allow for the re-equilibration of demand and supply through changes in prices and output within the region of interest, as well as interactions with the economy outside this region. The dynamic component calculates impacts over time relative to a baseline without the reuse activity but does not generally capture changes in production processes and technology. These models are designed to estimate regional changes in employment, output, income, and other impacts, partially accounting for transfers that could draw economic activity away from other areas to the reused site. However, they only partially account for general equilibrium effects, as they often have an incomplete treatment of capital and money markets; international trade; and local, state, and federal government revenue constraints. These models are generally more expensive than input-output models.

Box 8.1 - Economic Impacts of Land Revitalization Programs in Baltimore

Creason (2008) conducted an EIA of land revitalization at 16 formerly contaminated sites in the City of Baltimore, Maryland using a variety of descriptive and predictive tools. Baltimore, which has many abandoned industrial properties and a high poverty rate, provided an intriguing opportunity to examine the impacts of land reuse.

Three descriptive tools—location quotients, base theory and shift-share analysis—allowed the author to identify recent developments in the local economy, such as the loss in output and jobs in the manufacturing sector. These losses have been offset in part by growth in the fields of education, finance and health care, which now comprise a larger share of Baltimore's economy than they do nationally. These trends suggest that sites redeveloped as office space might have greater economic potential than those suitable for heavy industry, for instance.

The author investigated how redevelopment has affected the economy relative to a hypothetical baseline scenario in which businesses were not established at the 16 sites. He estimated the number of on-site jobs created across all sites using information on each site's size and Department of Energy figures on employees per square foot for each type of industry. He used these data as inputs into two predictive models to estimate additional effects. The IMPLAN input-output model estimated the on-site increase in output, the effect on other industries, the effects from worker spending, and the total employment impact. REMI's dynamic forecasting model calculated these same effects, as well as the demographic changes resulting from reuse and the distribution of gains in employment and output among residents in the City of Baltimore, surrounding counties, the rest of Maryland, and the remainder of the United States.

Creason found that while both models forecasted increases in employment and output from land revitalization relative to the baseline, the projected distribution of the gains differed according to the two models. IMPLAN estimated a $1.6 billion boost in total output and a 13,000 worker increase in employment in Baltimore City. The more sophisticated REMI estimated a much smaller impact in the city but found large spillover effects as commuters from other counties filled many of the new positions created through redevelopment. REMI also projected that minority and low-income residents filled many of the new positions and that state sales taxes and local property tax revenues rose, impacts not estimated by IMPLAN. The author found the dynamic forecasting model to provide more credible and comprehensive impact measures than the simpler input-output model.

Regional Economic Models, Inc.'s (REMI) Policy Insight model offers a detailed representation that projects annual impacts including output, labor and capital, demographics, market share, wages, prices and production costs at the regional level. The integration of firm and demographic trends allows REMI to estimate, for example, how new jobs are distributed among local residents, new migrants or commuters living in neighboring counties.

REMI's ability to project employment and income by income and minority group makes it useful for equity assessment as well as EIA. Creason (2008) used REMI to estimate the economic impacts of redeveloping 16 formerly contaminated sites in Baltimore, Maryland as a counterpoint to his IMPLAN analysis (see Box 8.1).

One advantage of REMI over input-output models such as IMPLAN is that it allows for local price and wage changes, which can produce more moderate estimates of economic impacts. However, like input-output models, REMI tends to overestimate the impacts of land cleanup and redevelopment. The model does not include a full representation of government budget constraints and therefore can miss important tax interaction effects. For example, in the case of a local program or regulation that results in land cleanup and reuse that is fully or partially government-funded, the model does not account for the region's need to finance the project, and the interaction of those effects with the impacts of the redevelopment. In other words, the project is modeled as if it were free – there is no opportunity cost of investing in land cleanup and reuse over some alternative project. In the model, personal incomes are unaffected as the government does not have to raise additional revenue or cut spending to fund the project. These assumptions lead to inaccurate predictions of regional employment increases. If the private sector finances the cleanup and reuse, analysts should account for private sector expenditures in REMI so that economic impacts associated with these costs are included in the analysis.

In general, analysts should exercise caution when presenting estimates of economic impacts from REMI or other dynamic forecasting models. An effort to identify research examining the accuracy of these estimates by comparing predicted effects to the effects actually experienced after a policy was unsuccessful. Such a comparison would be tricky in most cases because of the difficulty in isolating the effects of the policy in the absence of many other economic variables that might be influential.

Finally, regional models useful for EIA are likely to be inadequate for capturing net national effects, in which employment or output gains in the region benefiting from the reuse are often offset by losses in other regions of the country. As mentioned previously in this chapter, it is important to ensure that analysts are measuring the net impacts within the geographic region of interest. For national regulations or programs, this would be the entire country, making regional models inadequate.

8.3.2.3 Other Econometric Models

Other econometric models could prove useful for investigating a variety of land cleanup and reuse impacts and equity issues. Analysts can run regression models to estimate the effect of cleanup and reuse activities on outcomes such as income and demographics. For instance, Greenstone and Gallagher's (2008) quasi-experimental study of the Superfund remedial program (discussed in Box 6.2) examined whether average income, population density and demographic composition changed more in census tracts with NPL sites than in tracts containing sites that just missed being listed on the NPL. Banzhaf and Walsh (2008) examined the change in neighborhood population density and income in response to changes in air pollution from Toxics Release Inventory (TRI) sites. The authors used difference-in-difference and matching estimators to control for potentially confounding neighborhood characteristics that affect the location of TRI sites. A meta-analysis of 48 studies found that minority populations were disproportionately located near Superfund and other hazardous sites (Ringquist 2005). Regressions can also be used to investigate changes in the proximity of sub-populations to environmental hazards and to commercial establishments and other amenities.

These models have demanding data requirements and pose challenges similar to those discussed in Section 6.3.1 in the context of property value models. Econometric models of cleanup and reuse impacts could require data over time covering the pre- to post-reuse period, and analysts must address the issue of omitted variable bias. Many of these models estimate impacts occurring over a longer time frame than the standard input-output or dynamic forecasting models. Quasi-experimental approaches can help establish land reuse cause and effect, parsing to what extent post-reuse conditions can be attributed to cleanup and reuse rather than confounding factors (Howland 2007).

8.3.2.4 Recommendation, Advantages and Limitations

Several predictive approaches allow analysts the opportunity to assess the impacts of land reuse activities at the regional level on measures like employment and output in relation to a baseline scenario without land redevelopment. Available models differ in ease of implementation and credibility of results. Some advantages and limitations of predictive models and recommendations for applying them include:

Advantages

- ♦ These methods can calculate employment and output impacts beyond those on the site itself.
- ♦ Some models can project demographic changes in response to land cleanup and reuse activities, which could also be useful for equity assessment.
- ♦ These models can assess whether economic changes can be attributed to reuse activities and whether impacts represent gross or net changes for the region.
- ♦ These models are more appropriate for multi-site analysis.

Limitations

- ♦ Predictive models require considerable resources to implement. They often have demanding data requirements, can be costly, and call for analysts with specialized training.
- ♦ The incomplete representation of the economy and lack of government budget constraints mean that these models tend to overestimate output and employment impacts.
- ♦ Regional models such as IMPLAN and REMI are rarely appropriate for analyzing national programs or regulations for a variety of reasons, including that they fail to fully account for offsetting effects in other regions.
- ♦ These models also are generally not appropriate for analyzing long-term impacts because they fail to account for changes in production processes, technology and trade patterns.
- ♦ Analysts should interpret estimates of economic effects such as number of jobs from predictive models with caution. There is little research affirming the accuracy of such predictions.

Recommendations

- ♦ Economic impacts such as output and employment should be calculated as net changes from the no-action baseline within the specified geographic area of interest, which can be local, regional and/or national.
- ♦ Estimating the net change in jobs resulting from cleanup and reuse is a separate issue from determining the social welfare impacts of hiring new workers.

- Dynamic forecasting models like REMI provide more realistic regional impact estimates than input-output models, though they still have limitations and are usually more expensive.
- It is important to use the same assumptions and input parameters for EIA and BCA when relevant.
- Input-output and dynamic forecasting models such as IMPLAN and REMI are designed for regional analysis and should not be used to assess economic effects at the national level.
- They should not be used to analyze effects in the long term.

8.4 SUMMARY

EIA allows analysts to study the effects of land cleanup and reuse efforts on regions, industries and socioeconomic groups. It is often most useful for analysts targeting a specific contaminated site or a region that hosts multiple sites. When presenting the findings of an EIA, it is important to distinguish them from BCA results. Analysts should also clearly report and justify the geographic scale of analysis and whether the study accounts for possible transfers or losses from areas within or outside the region of interest.

9 Areas for Future Research

Assembling the information for this *Handbook* gave insight that there are more unanswered questions about assessing the benefits, costs and impacts of land cleanup and reuse than answered ones. This chapter compiles the ideas for research raised by the preceding chapters, as well as new ones including several proposed by external reviewers.[68] Focus is placed on ideas that would provide practical guidance to policy analysts.

9.1 A Consistent Architecture for Evaluating Land Cleanup Policy

Establishing a consistent approach to evaluating benefits and costs of land cleanup and reuse could improve the quality of BCA. It would involve making explicit the logic for evaluating land cleanup rules or activities; defining consistent categories of benefits and costs; and setting out standard approaches for estimating the values of those categories (or describing them qualitatively). Setting up such an architecture could improve transparency and consistency across benefit-cost analyses and reduce the likelihood of redundant or inappropriate benefit categories.

There is also a need to recognize the potential integrated roles for economic impact measures and BCA. A more expansive architecture for land cleanup analysis might include specific categories of economic impacts as well as benefits and costs. Some impacts, depending on the interests of the evaluator and the nature of the specific activity or program, might enhance the interpretation and understanding of a corresponding BCA. Similarly, a good grasp on benefits and costs seems likely to improve the interpretation of certain economic impacts, such as agglomeration or job effects. Future research could develop case studies that demonstrate how to assemble the various pieces into the proposed architecture. Having a carefully considered and consistent architecture could improve researchers' and policymakers' understanding of, and ability to compare, cleanup activities.

9.2 Partial versus General Equilibrium Analysis of Land Cleanup Policy

The peer review effort targeting this *Handbook* was not unlike the feedback from the 2006 NCEE-LRO Workshop. Both highlighted that among experts in the field of environmental economics, there is considerable difference of opinion on the importance of general equilibrium effects for benefits analysis of individual cleanups (Smith 2011). Thus the area seems ripe for further research. How inadequate are models that ignore the importance of sorting among households and producers following a contamination event or cleanup activity for estimating the value of land cleanup? How big a misspecification is it to ignore the potential change in WTP for cleanup associated with new equilibrium values of household preferences and income? Finally, how does such a misspecification affect the appropriate use and interpretation of the resulting parameter estimates in a policy scenario?

There is perhaps greater agreement within the profession that national level cleanup programs should consider general equilibrium effects. This helps refine the research goal to an exploration of the scale and scope of the program under analysis and the need for, and framing of, the partial versus general equilibrium analysis. A finer point that would benefit from the attention of researchers is the importance of agglomeration effects on the re-sorting of stakeholders in the

[68] The first four ideas are directly attributable to Smith's Peer Review Report (2011).

land market. A related and more fundamental question is how agglomeration might affect the measurement of land attributes in the first place.

9.3 Understanding and Expanding the Assortment of Property Value Models

For policy analysts to make the best practical use of estimates from property value models, better connections are needed between policy questions and the current assortment of such models. Chapter 6 outlined important distinctions between estimation, interpretation and policy uses of property value models. A potentially useful exercise would be to develop some hypothetical analytical questions that might call for different approaches to property value analysis. The exercise could examine recent additions to the assortment of property value models and distinguish between the interpretation of their estimates and the interpretation of estimates from older models. The objective would be to establish clearer connections between specific policy and analytical questions and estimated treatment effects.

Future research might pay particular attention to the discrepancy between capitalization and WTP estimates derived from property value models evaluating land cleanup and reuse. Exploring factors with which the discrepancy varies, such as the analysis timeframe would be informative, as would evaluating how and when it would be appropriate to transfer estimates for use in policy analysis. Another specific research question of particular interest to policy analysts concerns modeling the discrete change that occurs when land is contaminated or remediated. An assessment of whether certain models are more or less appropriate for estimating WTP for non-marginal changes in cleanup status would be useful.

A different issue concerning property value models is especially pressing in the current economic climate of recession and high rates of unemployment. The hedonic framework assumes that the housing market is in equilibrium, with a housing supply that equals demand. The recent pattern of foreclosure and abandonment in several major housing markets calls into question the relevance of this equilibrium concept, and suggests a need to better model long-term disequilibria. Research should consider the potential effect of disequilibrium in the housing market on what is revealed by property value models. Both conceptual and empirical analyses are warranted. Understanding the effects of dysfunction in regional housing markets may help in understanding situations with limited transactions near contaminated sites. Studies designed to track whether housing markets are clearing in relation to regional and national conditions could also help inform models of the potential restorative effects of site cleanup and land reuse on local markets.

A reduction in the number of housing market transactions has been associated with contaminated sites and is analogous to the effect of economic recession. While there is a plethora of research on the effect of contamination or cleanup on the *values* of nearby properties, far fewer papers have examined the effect on transactions *rates*. The impact of imperfect site information, or associated stigma, on sales rates and land productivity remains limited. The magnitude of these effects on social welfare could be substantial. Analysts would benefit from measures of welfare losses from reduced transactions rates due to a nearby contaminated property or gains from increased transactions rates due to cleanup. This idea echoes a Science Advisory Board panel recommendation to revise a hedonic meta-analysis of the Superfund program to consider whether distance from program sites affected property transaction rates as well as sales prices (U.S. EPA 2006a).

9.4 EXPLORING LAND REUSE

Past research of the effects of land cleanup has often overlooked the importance of reusing remediated sites. Analysts of land cleanup activities are interested in research that extends beyond the end of remediation to include the effects of reuse itself or perhaps even different categories of reuse (e.g., agricultural, recreational, or residential).

The connection between reuse of remediated land in densely populated areas and the preservation of greenfields on the outskirts of a metropolis is a pressing research need for analysts addressing the economic impacts of cleaning and reusing urban brownfields. Under what conditions should urban land reuse be expected to cause greenfield preservation? Are there factors that can be associated with different brownfield/greenfield offset ratios or is the ratio so variable from location to location as to be impossible to generalize? How big are the benefits from averting damages to greenfields and taking advantage of existing urban infrastructure?

9.5 TWO OBSCURE BENEFIT CATEGORIES

Environmental economists studying land cleanup routinely refer to potential nonuse benefits from remedial activities. Descriptions of these types of benefit sources or categories have been difficult to locate. Research that explored nonuse benefits would be informative and might include a characterization of the nature of such benefits as well as evidence that they are real.

Finally, empirical work linking land cleanup and reuse activities to peer group effects, especially in depressed neighborhoods would be useful. Does cleaning up existing contaminated sites lead to positive community effects that extend beyond the workers and homeowners directly affected by the cleanup? Analysts would benefit from research exploring this question.

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All websites referenced in the *Handbook* were accessed on July 11, 2011.

Appendix: Data Sources for EPA Cleanup Programs

General Data Sources

The Pollution Abatement Costs and Expenditures (PACE) survey is the most comprehensive national source of pollution abatement costs and expenditures related to environmental protection for the manufacturing sector. Data is available for 1973 to 1986, 1988 to 1994, 1999 and 2005 (http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/pace2005.html).

Cleanups in My Community (http://iaspub.epa.gov/Cleanups/) provides interactive maps, aerial photography and cleanup progress profiles of sites within a search area that are being or have been cleaned up under the RCRA Corrective Action, Superfund or Brownfields programs. Users may search for hazardous waste cleanup sites by address, city, county, state, zip code, watershed, or latitude/longitude coordinates.

Data.gov (http://www.data.gov) is an online data repository managed by the Federal Government to provide the public with access to data collected by federal agencies. It contains data sets collected by EPA's land cleanup programs including Superfund, RCRA and Brownfields.

EPA Regulatory Impact Assessments include estimates of the expected social costs, and sometimes expected social benefits, of environmental regulations.

RCRA Corrective Action Program

RCRAInfo (http://www.epa.gov/enviro/html/rcris/index.html) is a national program management and inventory system of RCRA hazardous waste handlers. It contains a wide range of information from firms that generate, treat, store, transport, and dispose of hazardous waste.

Envirofacts (http://www.epa.gov/enviro/index.html) provides information on the location of hazardous waste facilities.

Superfund Program

Removals Program

Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) (http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm) contains the total number of removal actions performed each year. It includes information on official actions, priority level, and organization(s) with primary responsibility. Some sites include information on contaminants and media.

Action memoranda summarize the site evaluation and/or engineering evaluation/cost analysis prepared for each site. They typically exist only as paper records stored at regional EPA offices or as individual documents posted online for a site rather than in a centralized database.

Remedial Program

Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) (http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm) includes location, contaminants, concentrations, media, and status of cleanup. For many, but not all sites, it also includes risk score according to the Hazard Ranking System, as well as Five-Year Reviews and site fact sheets.

Records of Decision and **remedial investigations/feasibility studies** contain risk information. Risk is assessed according to the Hazard Ranking System, which considers contaminants and human exposure routes. Exposure and risk data for the maximally exposed individual are available for most sites in individual baseline risk assessments, but are not compiled in a single place. Data for typical individuals and population exposure are usually not available.

The Superfund Redevelopment (SURE) Database contains information on planned and actual site reuse, including type of land use, status of the use, pre-cleanup and post-cleanup use, and basic economic data.

Federal Facilities Response Program

Data on federal sites on the NPL are available through CERCLIS.

Federal and State Underground Storage Tank (UST) Programs

All data collection is at the state level; no national database of site specific information exists. Data collected by states vary.

States are required to report semi-annually to EPA on the number of active and closed UST systems, confirmed releases, emergency responses, cleanups initiated, and cleanups completed. Information is available for approximately 50 USTfields Initiative pilot projects that were awarded up to $100,000 each to assess, clean up, and make ready for reuse high-priority petroleum-impacted sites (http://www.epa.gov/oust/rags/ustfield.htm).

The UST Corrective Action Program State Policy Database (http://www.gsi-net.com/USTPolicyDatabase/start.htm) is hosted online by the American Society for Testing and Materials (ASTM) and summarizes UST corrective action policies established by state environmental regulatory agencies.

Brownfields Program

Assessment, Cleanup and Redevelopment Exchange System (ACRES) (http://www.epa.gov/brownfields/pubs/acres/index.htm) is an online database for Brownfields grantees to electronically submit data directly to EPA.