Chapter 3: Better Protected Land

Indicators that were selected and included in this chapter were assigned to one of two categories:

- **Category 1** –The indicator has been peer reviewed and is supported by national level data coverage for more than one time period. The supporting data are comparable across the nation and are characterized by sound collection methodologies, data management systems, and quality assurance procedures.
- **Category 2** –The indicator has been peer reviewed, but the supporting data are available only for part of the nation (e.g., multi-state regions or ecoregions), or the indicator has not been measured for more than one time period, or not all the parameters of the indicator have been measured (e.g., data has been collected for birds, but not for plants or insects). The supporting data are comparable across the areas covered, and are characterized by sound collection methodologies, data management systems, and quality assurance procedures.

3.0 Introduction

The U.S. landscape can be characterized in many different ways—by its diversity and distribution of natural resources, by its complex pattern of land uses reflecting population distribution and management strategies, and by the various ecological systems that provide habitat for thousands of plant and animal species. This landscape is continuously changing due to population growth, the demand for resources and energy, and changing land management practices.

Our nation's land provides the foundation on which cities are built and from which food and other resources are derived to support the population. At the same time, land used for these purposes can be changed by pollution, waste disposal, and various physical processes (e.g., land clearing) that can change natural processes, such as the hydrologic cycle. Numerous laws and practices have been implemented—especially over the last 30 years—to help protect human health and ecosystems from these types of human actions.

This chapter addresses the types, extent, and uses of land in the geographic area of the U.S., which comprises approximately 2.3 billion acres of land and water (U.S. Census Bureau, 2001). This area includes all 50 states, as well as Puerto Rico, American Samoa, Guam, the Northern Mariana Islands, Palau, and the U.S. Virgin Islands. In total, 2.263 billion acres of the U.S. are land, while 116 million acres are water. This land acreage is the basis for all calculations of percentages in this chapter, unless otherwise noted.

Population growth is probably the single most important factor that has changed and continues to change the land environment of the U.S. The use of land is, to a major extent, a function of human needs and population density. According to the 2000 Census, more than 281 million people live on our nation's land. The U.S. has added at least 20 million people per decade to its population over the last 50 years, and in the last decade (1990-2000), the U.S. population has increased by more than 32 million (13 percent) (Exhibit 3-1). The density of population has also continuously increased, although not evenly across the country (Exhibit 3-2). According to the 2000 Census, the average density of people across our nation is approximately 0.125 people per acre. This represents a significant change from the first census of population, conducted in 1790, showing only 0.007 people per acre (U.S. Census Bureau, 2001).

The exponential growth in the U.S. and world population has created demands for resources and uses of land that have major effects on both human health and ecological condition. The land indicators outlined in this chapter are descriptors of the status, trends, and effects of various conditions and land practices. These indicators are often limited in their capacity to paint an accurate picture of the effects of various human practices, due to incomplete, inconsistent, or dated data.

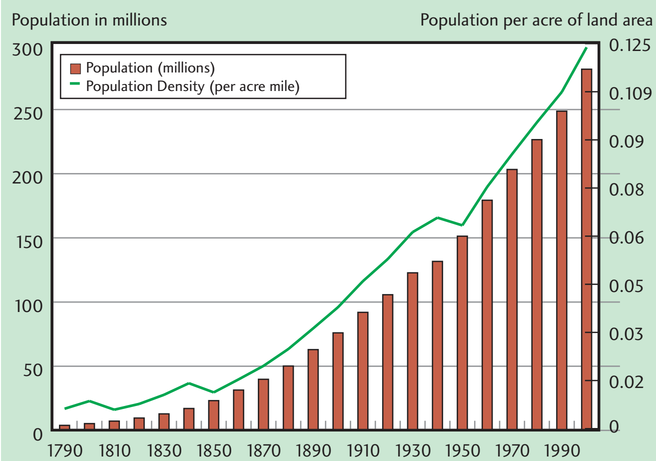
The specific issues explored in this chapter include changing uses of land for development, agriculture, and forest management; the use and presence of chemicals in the form of pesticides, fertilizers, and toxic releases; the generation and management of various types of waste; and the extent of contaminated lands. The chapter poses fundamental questions about these issues and their health and ecological effects, and it uses indicators drawn from well-reviewed data sources to help answer those questions. Exhibit 3-3 lists these questions and indicators, and identifies the chapter section where each indicator is presented.

The chapter is divided into four main sections:

- Section 3.1 examines the extent of various ecological systems and land uses in the U.S.
- Section 3.2 looks at the extent and potential disposition of chemicals used or managed on land.
- Section 3.3 addresses waste generation and management on land and the extent of contaminated lands.
- Section 3.4 reviews the challenges and data gaps that remain in assessing the condition of our nation's land.

Each of the topic sections (e.g., land use, chemicals, waste) also considers what is currently known about associated human health and ecological effects.

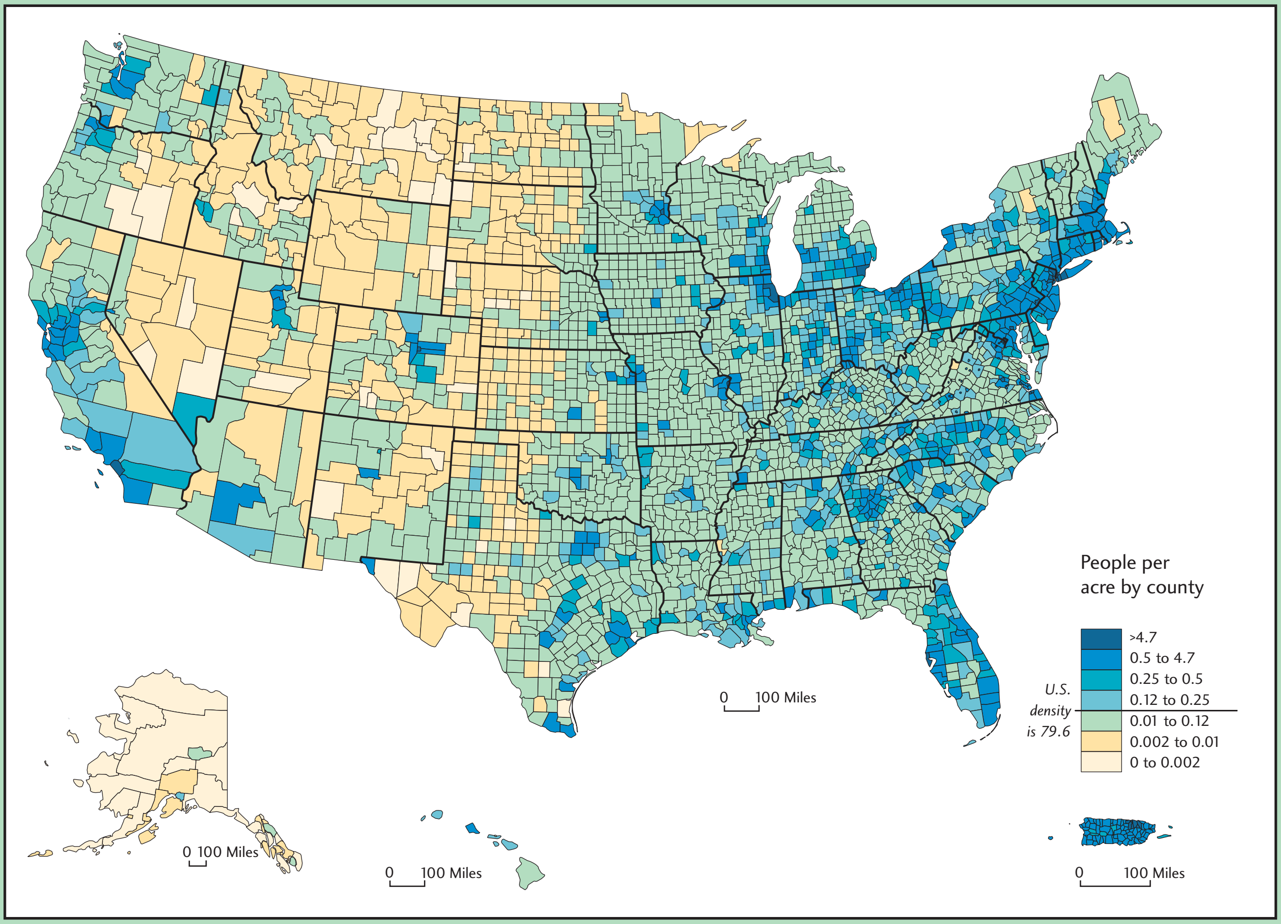
Exhibit 3-1: Population and population density, 1790-2000



Note: Large amounts of land area were added to the United States in the early 1800s (Louisiana Purchase, 1803), mid-1800s (adding the present states of Oregon, Washington, Idaho, California, Nevada, Utah, and parts of Colorado, Kansas, Arizona, and New Mexico), and in 1959 (Alaska and Hawaii statehood). These land increases explain population density decreases during these periods.

Source: U.S. Census Bureau, *Statistical Abstract of the United States 2001: The National Data Book*. Washington DC: U.S. Census Bureau, 2001.

Exhibit 3-2: United States population density by county, 2000



Source: Brewer, Cynthia A. and Trudy A. Suchan. *Mapping Census 2000: The Geography of U.S. Diversity.* June 2001.

Numerous gaps in the data exist that make it difficult or impossible to answer some of the questions posed about the condition of our nation's lands. The gaps and limitations of data are described briefly under each question and in more detail at the end of the chapter.

There are several major sources of data that contribute to this chapter, and a report titled *The State of the Nation's Ecosystems,* developed by The H. John Heinz III Center for Science, Economics and the Environment (The Heinz Center, 2002). These data sets contribute directly and indirectly to many of the indicators throughout the chapter.

Exhibit 3-3: Land – Questions and Indicators

Land Use

Question	Indicator Name	Category	Section
What is the extent of developed lands?	Extent of developed lands	1	3.1.1
	Extent of urban and suburban lands	2	3.1.1
What is the extent of farmlands?	Extent of agricultural land uses	1	3.1.2
	The farmland landscape	2	3.1.2
What is the extent of grasslands and shrublands?	Extent of grasslands and shrublands	2	3.1.3
What is the extent of forest lands?	Extent of forest area, ownership, and management	1	3.1.4
What human health effects are associated with land use?	No Category 1 or 2 indicator identified		3.1.5
What ecological effects are associated with land use?	Sediment runoff potential from croplands and pasturelands	2	3.1.6

Chemicals in the Landscape

Question	Indicator Name	Category	Section
How much and what types of toxic substances are released into the environment?	Quantity and type of toxic chemicals released and managed	2	3.2.1
What is the volume, distribution, and extent of pesticide use?	Agricultural pesticide use	2	3.2.2
What is the volume, distribution, and extent of fertilizer use?	Fertilizer use	2	3.2.3
What is the potential disposition of chemicals from land?	Pesticide residues in food	1	3.2.4
	Potential pesticide runoff from farm fields	1	3.2.4
	Risk of nitrogen export	2	3.2.4
	Risk of phosphorus export	2	3.2.4
What human health effects are associated with pesticides, fertilizers, and toxic substances?	No Category 1 or 2 indicator identified		3.2.5
What ecological effects are associated with pesticides, fertilizers, and toxic substances?	No Category 1 or 2 indicator identified		3.2.6

Waste and Contaminated Lands

Question	Indicator Name	Category	Section
How much and what types of waste are generated and managed ?	Quantity of municipal solid waste (MSW) generated and managed	2	3.3.1
	Quantity of RCRA hazardous waste generated and managed	2	3.3.1
	Quantity of radioactive waste generated and in inventory	2	3.3.1
What is the extent of land used for waste management?	Number and location of municipal solid waste (MSW) landfills	2	3.3.2
	Number and location of RCRA hazardous waste management facilities	2	3.3.2
What is the extent of contaminated lands?	Number and location of Superfund National Priorities List (NPL) sites	2	3.3.3
	Number and location of RCRA Corrective Action sites	2	3.3.3
What human health effects are associated with waste management and contaminated lands?	No Category 1 or 2 indicator identified		3.3.4
What ecological effects are associated with waste management and contaminated lands?	No Category 1 or 2 indicator identified		3.3.5

3.1 Land Use

Land ownership and the management objectives of the owners tend to determine how land is used; thus, U.S. lands are used for many different purposes. Nearly 28 percent of the nation (630 million acres) is owned and managed by the federal government. State and local governments manage another 198 million acres (GSA, 1999). The more than 828 million acres of federal, state, and local government lands in the nation are managed for various public purposes. In contrast, the approximately 1.419 billion acres of private and tribal land are more likely to be managed in the interests of their owners, with various land use constraints imposed by zoning and other regulations (GSA, 1999; USDA, NRCS, 1997; Alaska DNR, 2000).

Management objectives are constantly changing on private and public lands and can have both positive and negative effects on the natural environment and human health. Such effects include loss of native habitat to agricultural practices; loss of prime agricultural lands to urban/suburban development; changes in patterns of runoff as a result of impervious surfaces, stream flow, dams, or irrigation systems; habitat restoration based on land reclamation; and urban/suburban development on previously contaminated land.

There are differing estimates of the extent of various land uses. Those discussed in the context of the following questions are often due to different classifications, definitions, approaches to data collection, and the timing of data collection and analysis. Land cover and land use represent two different concepts and both are discussed in this section. Land cover is essentially what can be seen on the land—the vegetation or other physical characteristics—while land use describes how a piece of land is being used (or not) by humans. In some cases, land uses can be determined by cover types, which are visible (e.g., the presence of housing indicates residential land use). Often, however, more information is needed for those uses that are not visible (e.g., lands leased for mining, "reserved" forest land, shrublands with grazing rights). Techniques for assessing land cover and land use vary, with different data required to accurately assess extent and practices. Remotely sensed data are increasingly being used to track land cover. When combined with knowledge of local land use regulations or other information, such data can be useful for tracking land use.

Six questions are posed in this section to examine the extent of various ecological systems and land uses, including development, agriculture, and forest management. The questions considered are:

- What is the extent of developed lands?
- What is the extent of farmlands?
- What is the extent of grasslands and shrublands?
- What is the extent of forest lands?
- What human health effects are associated with land use?
- What ecological effects are associated with land use?

Tracking national patterns of land use and activities that affect the land can be challenging, primarily because land use is regulated by many levels of government and also because of the significant variations in land cover, geography, and land activities nationwide. Data produced by different agencies at different levels of government must be integrated and analyzed continually to gain a national perspective of patterns and trends.

The primary information sources for this section include the National Resources Inventory (NRI) of the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS); the report titled *The State of the Nation's Ecosystems,* which was developed by The H. John Heinz III Center for Science, Economics and the Environment (The Heinz Center, 2002); and data from the Forest Inventory and Analysis (FIA) Program.

This section presents various activities related to land use and land cover. Two examples of activities for which indicators have not been identified, but that can have significant effects in different ways on land are 1) the formal protection or reservation of land for habitat or natural resources and 2) mining and extraction activities. Some data are collected locally and for federal lands (e.g., National Park acreage) or tracked for economic indicators, but the national picture of the extent of land reservation and mining is not generally available. A snapshot of what is known is described in the two sidebars.

PROTECTED LANDS

Across the U.S., lands are protected against or for certain uses in a variety of ways by federal, state, and local land managers and by private landowners. Local zoning ordinances, state and federal land management regulations, and land classifications are used to protect lands for habitat and natural uses. Federal land management agencies protect land in several different use classifications that provide varying degrees of protection. More than 4 percent of the nation is managed as wilderness. Of the 106 million acres of land now designated as federal wilderness, more than half are in Alaska (Wilderness Information Network, 2002). Millions of acres of lands are also protected in the National Park Service System, within the U.S. Fish and Wildlife Service refuge system, as USDA and Bureau of Land Management Wilderness Study Areas, in National Forest Roadless Areas, in the National Trails System, as National Wild and Scenic Rivers, in National Recreation Areas, in Research Natural Areas, and other areas. States also have established park systems, fish and wildlife areas, wilderness systems, and other areas of protected lands. Local government agencies also often manage parks. Conservation easements protect private lands by providing restrictions from development in perpetuity.

MINING AND EXTRACTION ACTIVITIES

The U.S. is the world's largest producer and consumer of energy, and yet there is no inventory of lands used for energy production. There are known to be 1,879 coal mines and associated facilities in the U.S (USGS, 2000a). The West, led by Wyoming, produces about half of the U.S. coal, primarily from surface mines. The Appalachia area, led by West Virginia and Kentucky, accounts for 37 percent of U.S. coal production, mainly from underground mines(DOE, November 2002). Other energy activities include 534,000 producing oil wells (ranging from one to millions of barrels of production per year). Top producing areas of oil and natural gas include the Gulf of Mexico, Texas, Alaska, California, Louisiana, Oklahoma, and Wyoming (DOE, November 2002). Eight uranium mines and 1,965 other mines and processing facilities produce most of the minerals and metals in the U.S (USGS, 2000b). About 5.4 billion metric tons of non-fuel mineral materials were removed in 2000. Overall, 97 percent was mined and quarried at the surface level, and 3 percent was mined underground. The major states in which mining for non-fuel minerals occurs are Nevada, Arizona, New Mexico, Minnesota, California, Florida, Texas, Michigan, Ohio, and Pennsylvania (USGS, 2000b). In addition to active mines, the U.S. Bureau of Land Management estimates approximately 10,200 abandoned hardrock mines are located within the roughly 264 million acres under its jurisdiction. Estimates of abandoned mines on public and private lands range from 80,000 to hundreds of thousands of small to medium-sized sites (DOI, Bureau of Land Management, 2002).

3.1.1 What is the extent of developed lands?

Indicators

Extent of developed lands
Extent of urban and suburban lands

Land development is a process of land conversion that changes lands from natural or agricultural uses to residential, industrial, transportation, or commercial uses to meet human needs. Land development has created urban and suburban ecological systems, which are areas where the majority of the land is devoted to or dominated by buildings, houses, roads, lawns, or other elements of human use and construction (The Heinz Center, 2002). Urban and suburban ecological systems are highly built up and paved, resulting in effects such as more rapid changes in temperature, increased runoff, and increased chemical contaminants than in more natural ecosystems. Plant and animal life is more heavily influenced by species introduced in horticulture and as pets, and native species may be more or less completely removed from large areas and replaced by lawns, gardens, and ornamentals (World Resources Institute, 2000).

The majority of Americans live in areas that are considered "developed land." Between 1950 and 2000, the number of Americans living in U.S. Census Bureau-defined urban areas increased from 64 percent to 79 percent of the total population (U.S. Census Bureau, 2001). Estimates vary widely on the amount of land considered developed in the U.S., depending on definitions of "developed" and different assessment techniques. For example, the Census Bureau definition is a measure of population density; not specifically a measure of actual land use or conversion of land. Census urban areas do not take into account low-density suburbs and other developed lands such as commercial or transportation infrastructure areas that do not include people. The Census definitions may underestimate lands that would be categorized as low-level residential or lands having dispersed development. (See the following sidebar for definitions used in this discussion.)

The two indicators presented in this section provide an estimate of the extent of developed land, with an estimate of urban and suburban lands as a subset of developed lands. These estimates were developed using different definitions and methodologies. The extent of "developed land" indicator uses a national statistical sample that takes into account various development types. The "extent of urban and suburban lands" indicator identifies densely developed areas classified using remotely sensed satellite data.

DEFINITIONS OF DEVELOPED AND URBAN/SUBURBAN LANDS

U.S. Census Bureau Definitions

Urbanized Areas and Urban Clusters. The Census Bureau describes urban areas as Urbanized Areas (UAs) and Urban Clusters (UCs). These are designations for densely settled areas, which consist of core census block groups that have a population density of at least 1,000 people per square mile and other surrounding census blocks that have an overall density of at least 500 people per square mile. UAs contain 50,000 or more people. UCs contain at least 2,500 people, but less than 50,000. Based on 2000 Census data, there are 466 UAs and 3,172 UCs comprising nearly 60 million acres (or 2.6 percent of the U.S. land area). These definitions and delineations of urban areas are used by the Office of Management and Budget to delineate the Census Metropolitan Areas, including Metropolitan Statistical Areas, which are used for various federal and state budget allocation purposes (U.S. Census Bureau, 2001).

USDA, NRCS, National Resources Inventory (NRI) Definitions

Developed land. A combination of land cover/use categories: Large urban and built-up areas, small built-up areas, and rural transportation land (USDA, NRCS, 2000a).

Urban and built-up areas. A land cover/use category consisting of residential, industrial, commercial, and institutional land; construction sites; public administrative sites; railroad yards; cemeteries; airports; golf courses; sanitary landfills; sewage treatment plants; water control structures and spillways; other land used for such purposes; small parks (less than 10 acres) within urban and built-up areas; and highways, railroads, and other transportation facilities if they are surrounded by urban areas. Also included are tracts of less than 10 acres that do not meet the above definition but are completely surrounded by urban and built-up land. Two size categories are recognized in the NRI: areas of 0.25 acre to 10 acres and areas of at least 10 acres.

Large urban and built-up areas. A land cover/use category composed of developed tracts of at least 10 acres—meeting the definition of urban and built-up areas.

Small built-up areas. A land cover/use category consisting of developed land units of 0.25 to 10 acres that meet the definition of urban and built-up areas.

Rural transportation land. A land cover/use category that consists of all highways, roads, railroads, and associated rights-of-way outside of urban and built-up areas, including private roads to farmsteads or ranch headquarters, logging roads, and other private roads, except field lanes.

The Heinz Report Definitions

Urban and suburban lands. An area is considered to be urban/suburban if a majority of the lands within a 1,000 foot by 1,000 foot area (pixel) fall into one of the four "developed" land cover types classified in the NLCD (low-density residential, high-density residential, commercial-industrial-transportation, or urban and recreational grasses). In outlying areas, clusters of pixels had to total at least 270 acres to be considered urban/suburban.

Indicator Extent of developed lands - Category 1

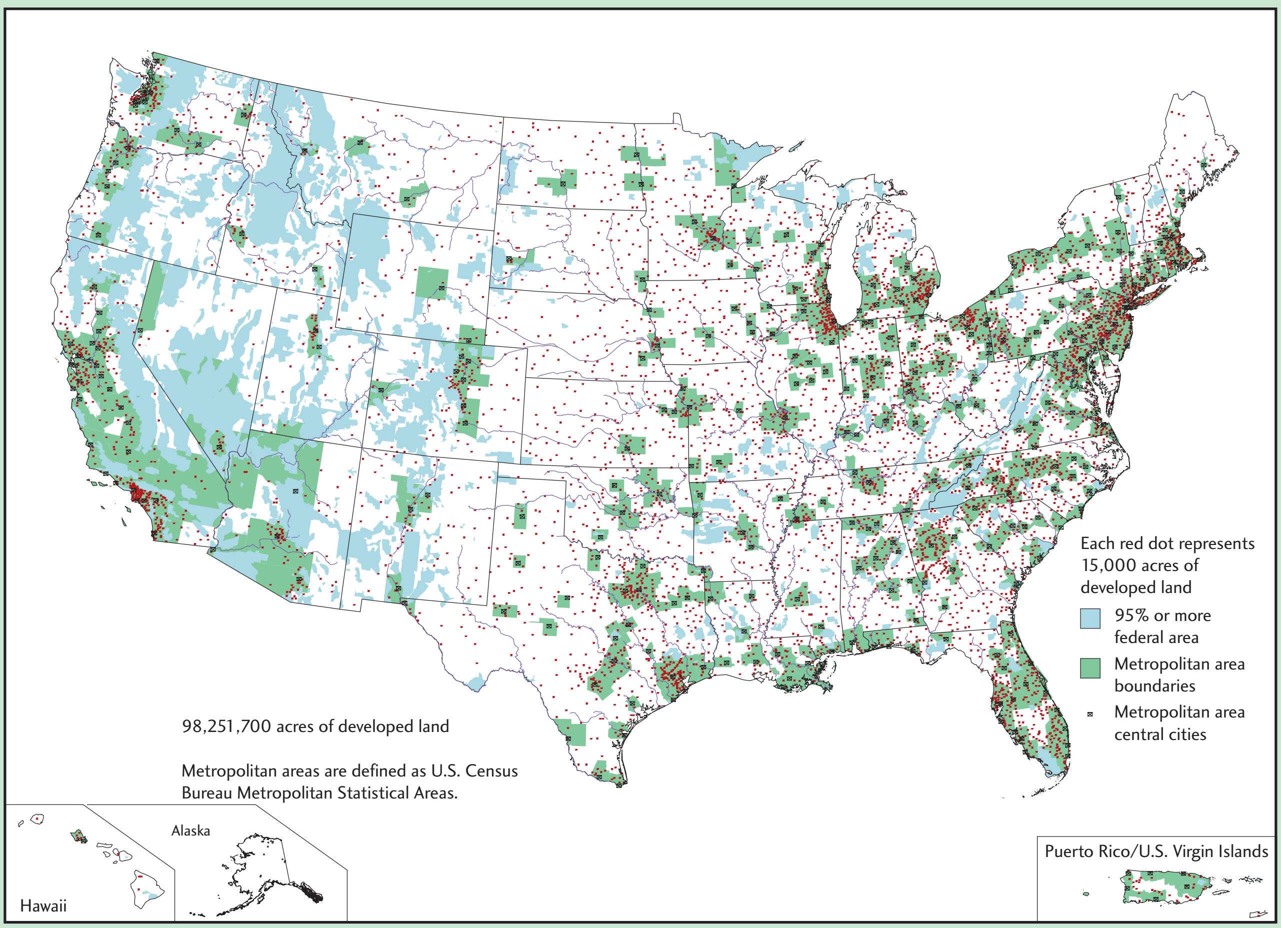
Land development generally results in significant changes in other land uses or cover types. This indicator provides a measure of how much developed land exists, where it is, and how it has changed. The indicator relies on national statistical data samples conducted every five years by the USDA NRCS.

What the Data Show

The NRI reports approximately 98 million acres of developed land in the U.S., not including Alaska (USDA, NRCS, 2001). This figure represents about 4.3 percent of the total land area. Exhibit 3-4 shows the distribution of non-federal developed lands nationwide. Each dot on the map represents 15,000 acres. The map displays the Census Metropolitan Area boundaries, which are larger in western states due to the large size of many counties. States along the Northeast corridor have the highest percentages of developed land, exceeding more than one-third of a state's area in some cases.

Between 1982 and 1997, developed lands increased by 25 million acres, primarily through conversion of croplands and forest lands (USDA, NRCS, 2000a). This represents a 34.1 percent increase. Developed lands as a percentage of the nation rose from 3.2 percent in 1982 to 4.3 percent in 1997 (USDA, NRCS, 2000a). The pace of land development between 1992 and 1997 was more than 1.5 times the rate of the previous 10 years. The distribution of changes in developed land varies nationwide, with extensive changes in the eastern part of the country from south to north.

Exhibit 3-4: Extent of non-federal developed land, 1997



Source: USDA, Natural Resources Conservation Service. National Resources Inventory, 1997, revised December 2000: Acres of Developed Land, 1997. 2000. (January 2003; *http://www.nrcs.usda.gov/technical/land/meta/m4974.html*).

Indicator | Extent of developed lands - Category 1 (continued)

Exhibit 3-5 depicts the change in developed land (urban and suburban areas and rural transportation land) by watershed in the 1982 to 1997 time frame.

Indicator Gaps and Limitations

The NRI data are limited in not providing data on Alaska and not assessing development on federal lands, including recreational development and transportation infrastructure.

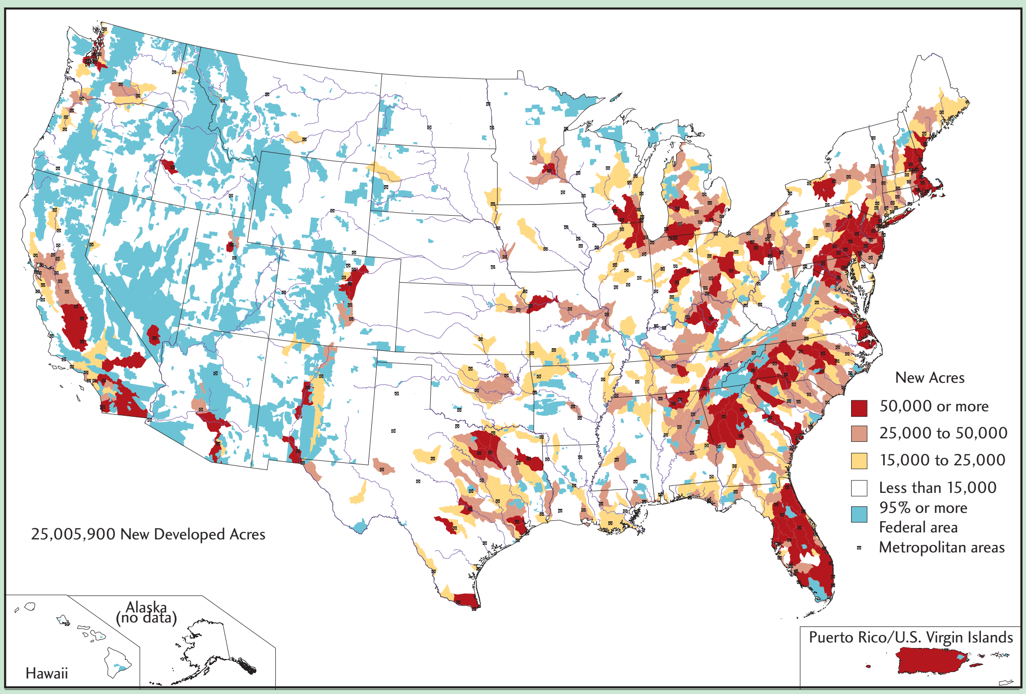
Data Source

Acreage estimates and map data presented for this indicator are from the National Resources Inventory, U.S. Department of Agriculture, Natural Resources Conservation Service, 1997 (Revised December 2000). (See Appendix B, page B-18, for more information.)

National Resources Inventory

The NRI is a longitudinal survey designed to assess conditions and trends of soil, water, and related resources on non-federal lands in the U.S. The NRI statistical sample involves approximately 300,000 sample units and 800,000 sample points on non-federal lands. The sample is a stratified two-stage unequal probability design that can be modified to address specific national survey goals or special studies. Stratification was developed county by county, based on the Public Land Survey System (PLSS) where possible, and on latitude/longitude, Universal Transverse Mercator Grid, or artificial superimposed lines when necessary. The national sampling varies across strata and ranges from 2 to 6 percent. The NRI measures numerous variables, which are then extrapolated as national totals. Variables include the following: soil characteristics, earth cover, land cover and use, erosion, land treatment, vegetative conditions, conservation treatment needs, potential for cropland conversion, extent of urban land, habitat diversity, and Conservation Reserve Program cover. NRI sample data are generally reliable at the 95 percent confidence interval for state and certain broad sub-state area analyses (Goebel, 1998).

Exhibit 3-5: Land development patterns, 1982-1997



Source: USDA, Natural Resources Conservation Service. National Resources Inventory, 1997, revised December 2000: Land Development, 1982-1997. 2000. (January 2003; *http://www.nrcs.usda.gov/technical/land/meta/m5009.html*).

Indicator Extent of urban and suburban lands - Category 2

Urban and suburban lands are considered a subset of developed lands and one of the ecological systems described in Chapter 5, Ecological Condition. These are highly developed areas and surrounding suburbs, including developed outlying areas above a minimum size. Acreage estimates are based on an analysis of the remotely sensed NLCD data conducted by the U.S. Geological Survey (USGS), Areas of at least 270 acres that are substantially covered with roads, buildings, concrete, and other hard surfaces must be identified to be classified and counted as urban/suburban (The Heinz Center, 2002). This definition excludes smaller built-up areas.

What the Data Show

Urban and suburban ecological systems occupied 32 million acres in the conterminous U.S. in 1992, or about 1.7 percent of that land area (The Heinz Center, 2002). This estimate was derived from a re-analysis of the 1992 NLCD. The analysis includes information on the amount and character of undeveloped land within urban/suburban areas. Most of the lands designated urban and suburban are in the South and Midwest, but they account for less than 2 percent of the land in those regions. In the Northeast, urban and suburban lands account for more than 5 percent of the landscape.

Indicator Gaps and Limitations

The NLCD database is derived from a one-time interpretation of satellite imagery of the nation from the early 1990s. Although limited by the ability to detect land use remotely based on spectral characteristics, NLCD data are available for all of the conterminous U.S. Original estimates of the NLCD indicated a total of 36.7 million acres of land in three different "developed" land cover classifications (low density residential, high density residential, and commercial/industrial/transportation) (The Heinz Center, 2002).

Data Source

Acreages presented for this indicator are derived from a re-analysis of the National Land Cover Data, a product of the Multi-Resolution Land Characteristics Consortium, which is a partnership between the U.S. Geological Survey; the U.S. Department of Agriculture, Forest Service; the National Oceanographic and Atmospheric Administration; and the EPA. (See Appendix B, page B-18 for more information).

3.1.2 What is the extent of farmlands?

Indicators

Extent of agricultural land uses
The farmland landscape

Farmlands represent one of the nation's major ecological systems and are discussed in Chapter 5, Ecological Conditions.(The Heinz Center, 2002). As noted in the sidebar, on the following page, croplands, which can include pasturelands and haylands, are at the heart of the farmland ecosystem. The broader "farmland landscape" also includes other lands that are not actively used for crop, pasture, or hay production. The composition of lands that surround croplands, such as forests, wetlands, or built-up areas, are discussed further in the "farmland landscape" indicator.

The U.S. produces a wide range of food crops, grains, and other agricultural products over vast areas of the country that are part of the farmland landscape (see adjacent sidebar). Agricultural lands can be thought of as all those lands that contribute to this production. Other words such as farmland, cropland, pastureland, rangeland, grazing land, or grassland are also used to describe aspects of agricultural lands. Some of these words define cover types, while others define land use. The areas overlap but do not necessarily coincide with each other. This situation creates challenges in establishing accurate estimates of extent. Under the discussion of the agricultural land use indicator, an effort is made to distinguish the various definitions and provide a measure of acreages. (Current definitions as used by the USDA NRCS NRI are shown in the sidebar that follows.)

Aside from the challenges of defining types of agricultural land, assessing the amount of land used for crops is an imperfect science, given the seasonality of agricultural practices and changes in economics and technology. As with developed land, estimates vary depending on the classification criteria and mapping or sampling methodologies. Until the 1950s, the amount of agricultural land needed to meet demands for food continued to grow, reaching a peak of more than a billion acres of cropland and rangeland in the mid 1960s. Since then, crop and farmland acreages have decreased and increased in cycles, as both economics and technology have changed demands and as production capabilities have increased.

Two indicators are considered on the following pages. The first assesses the extent of land used to grow food crops and forage. The second considers the farmland landscape, which includes not only land used for agricultural production but also adjacent areas.

NRI Land Cover Definitions for Agricultural Land

Cropland. A land cover/use category that includes areas used for the production of adapted crops for harvest. Two subcategories of cropland are recognized: cultivated and noncultivated. Cultivated cropland comprises land in row crops or close-grown crops and also other cultivated cropland, such as hayland or pastureland in a rotation with row or close-grown crops. Non-cultivated cropland includes permanent hayland and horticultural cropland.

Conservation Reserve Program (CRP). A federal program established under the Food Security Act of 1985 to help private landowners convert highly erodible cropland to vegetative cover for 10 years.

Pastureland. A land cover/use category of areas managed primarily for the production of introduced forage plants for livestock grazing. Pastureland cover may consist of a single species in a pure stand, a grass mixture, or a grass-legume mixture. Management usually consists of cultural treatments: fertilization, weed control, reseeding or renovation, and control of grazing. For the NRI, it includes land that has a vegetative cover of grasses, legumes, and/or forbs, regardless of whether it is being grazed by livestock.

Rangeland. A land cover/use category on which the climax or potential plant cover is composed principally of native grasses, grasslike plants, forbs or shrubs suitable for grazing and browsing, and introduced forage species that are managed like rangeland. This would include areas where introduced hardy and persistent grasses, such as crested wheatgrass, are planted and such practices as deferred grazing, burning, chaining, and rotational grazing are used, with little or no chemicals or fertilizer being applied. Grasslands, savannas, many wetlands, some deserts, and tundra are considered to be rangeland. Certain communities of low forbs and shrubs, such as mesquite, chaparral, mountain shrub, and pinyon-juniper, are also included as rangeland.
(USDA, NRCS, 2000a)

Indicator

Extent of agricultural land uses - Category 1

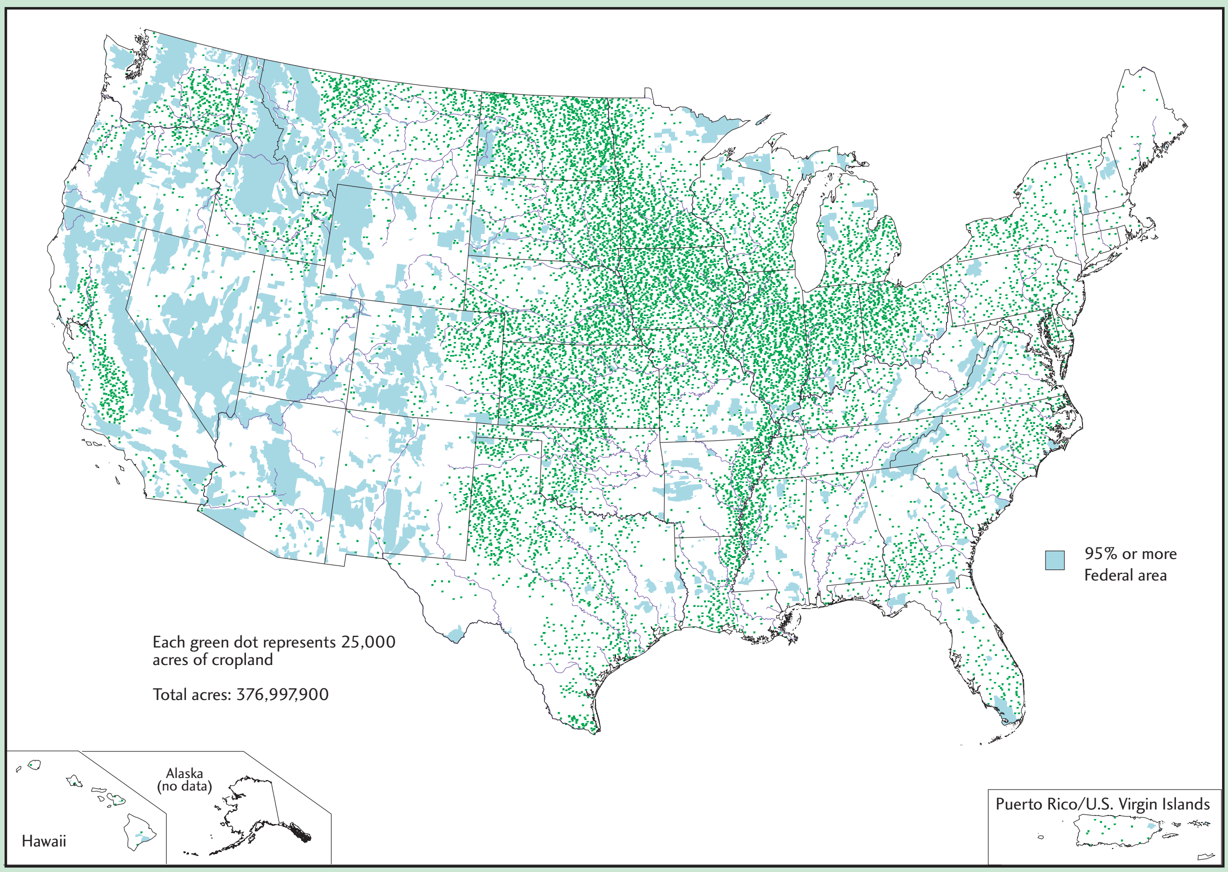
Land can be used for a variety of agricultural purposes. Two general categories are differentiated in this discussion. The first includes lands that are actively managed to cultivate food crops or forage. This category comprises croplands, or lands that grow perennial and annual crops such as fruits, nuts, grains, and vegetables; and pasturelands, or lands that are actively cultivated to produce forage for livestock. The second category includes lands that may be used to produce livestock as an agricultural commodity, but are not planted, fertilized, or otherwise intensively managed. These livestock production lands may be called grazing lands or rangelands and can include forest land, shrubland, and grassland, which are described in the following sections. Livestock production may also include concentrated animal feedlot operations, acreages of which are not included in this discussion.

What the Data Show

In 1997, the NRI identified nearly 377 million acres of cropland and more than 32 million acres of Conservation Reserve Program (CRP) land. CRP lands, as noted in the sidebar, are croplands that are set aside (farmers are provided incentives) for up to 10 years for conservation purposes, but that could be returned to crop production if the program ceased. This total equals nearly 410 million acres of land currently growing or specifically identified with the potential to grow crops in the U.S. (USDA, NRCS, 2000a) (Exhibit 3-6).

The NRI reports about 120 million acres of pastureland. As defined in the sidebar, pastureland includes land that has a vegetative cover of grasses, legumes, and/or forbs, regardless of

Exhibit 3-6: Extent of croplands, 1997



Source: USDA, National Resources Conservation Service. National Resources Inventory, 1997, revised December 2000: Acres of Cropland. 2000. (January 2003; www.nrcs.usda.gov/technical/land/meta/m4964.html).

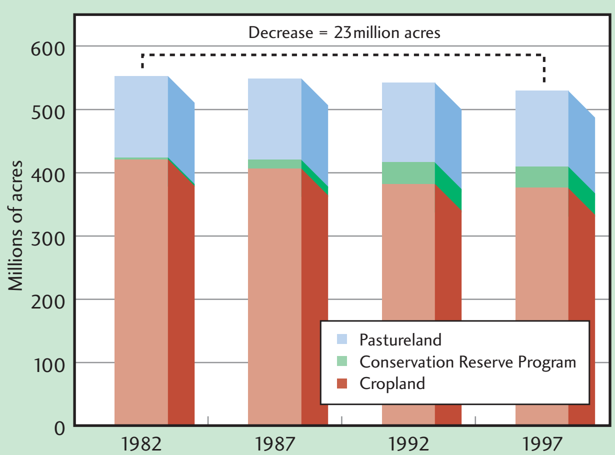
Indicator Extent of agricultural land uses - Category I (continued)

whether it is being grazed by livestock. It is usually managed to produce feed for livestock grazing, using fertilization, weed control, and reseeding. Thus the total estimate from the NRI for cropland, CRP land, and pastureland is 530 million acres.

The Heinz Center (2002), using four different sources of data, estimated that cropland, including pasture and haylands, covered between 430 and 500 million acres in 1997. For the most part, the report did not include CRP lands in its estimates. According to the 1992 NLCD, the U.S. had 510 million acres of agricultural land in the 1990s (EPA, ORD, 1992).

Grazing to support livestock production can potentially occur on pastureland, rangeland, and, in some cases, forest land. These lands can also be defined based on their cover type (e.g., grasslands, shrublands, or forested range). Not counting pastureland, the NRI identified nearly 406 million acres of non-federal rangelands and another 62 million acres of non-federal forest land that can be used for grazing livestock (USDA, NRCS, 2000a). In addition, according to estimates generated by the Bureau of Land Management, more than half of the federal land in the lower 48 states, or 244 million acres, is available for livestock grazing (DOI, 1994). The total of these estimates is 712 million acres of lands that may be used for grazing, but are not cultivated. Adding in the pastureland acreage results in 832 million acres of land that may be used for grazing livestock nationwide (excluding Alaska).

Exhibit 3-7: Change in cropland, Conservation Reserve Program (CRP) land and pastureland, 1982-1997



Source: USDA, Natural Resources Conservation Service. *Summary Report 1997 National Resources Inventory (revised December 2000)*. 2000.

Agricultural lands constantly shift among crop, pasture, range, and forest land to meet production needs, implement rotations of land in and out of cultivation, and maintain and sustain soil resources. Within these shifts, however, trends indicate a gradual decrease in cropland acreage. Between 1982 and 1997, cropland decreased 10.4 percent, from about 421 million acres to nearly 377 million acres (Exhibit 3-7). Of this 44 million acre decrease, however, 30.4 million acres are now enrolled in the CRP, resulting an 13.6 million fewer acres of cropland as a result of conversion to other land uses (USDA, NRCS, 2000a). During this same time frame, pastureland area decreased 9.1 percent, or about 12 million acres (USDA, NRCS, 2000a). The total change in acreage, considering lands in the CRP was 23 million fewer agricultural land acres in 1997 than in 1982.

Decreases in cropland have occurred particularly in the southern and southeastern part of the U.S. The distribution of change in cropland acreage is displayed in Exhibit 3-8. There are no comprehensive estimates of changes in acreages of grazing lands.

Indicator Gaps and Limitations

A specific objective of the NRI is to assess changes in cropland. Again, however, the ability to couple it with current remote sensing imagery would likely contribute to improved resolution and national mapping of cropland types (See the discussion about NRI data in the "Extent of Developed Land" indicator box).

There is no single, definitive, accurate estimate of the extent of cropland. Estimates of the amount of land devoted to farming differ because different programs use different methods to acquire, define, and analyze their data. Cropland is also a flexible resource that is constantly being taken in and out of production. The Heinz report used four different data sources to describe the range of estimates. The four data sets are not fully consistent, and comparisons are difficult to make. For example, the USDA Economic Research Service (ERS) and Census of Agriculture data include croplands in Alaska and Hawaii, while NRI does not. The ERS data used in the Heinz report estimate included CRP lands, while the Census of Agriculture and NRI estimates used by the Heinz report did not (The Heinz Center, 2002).

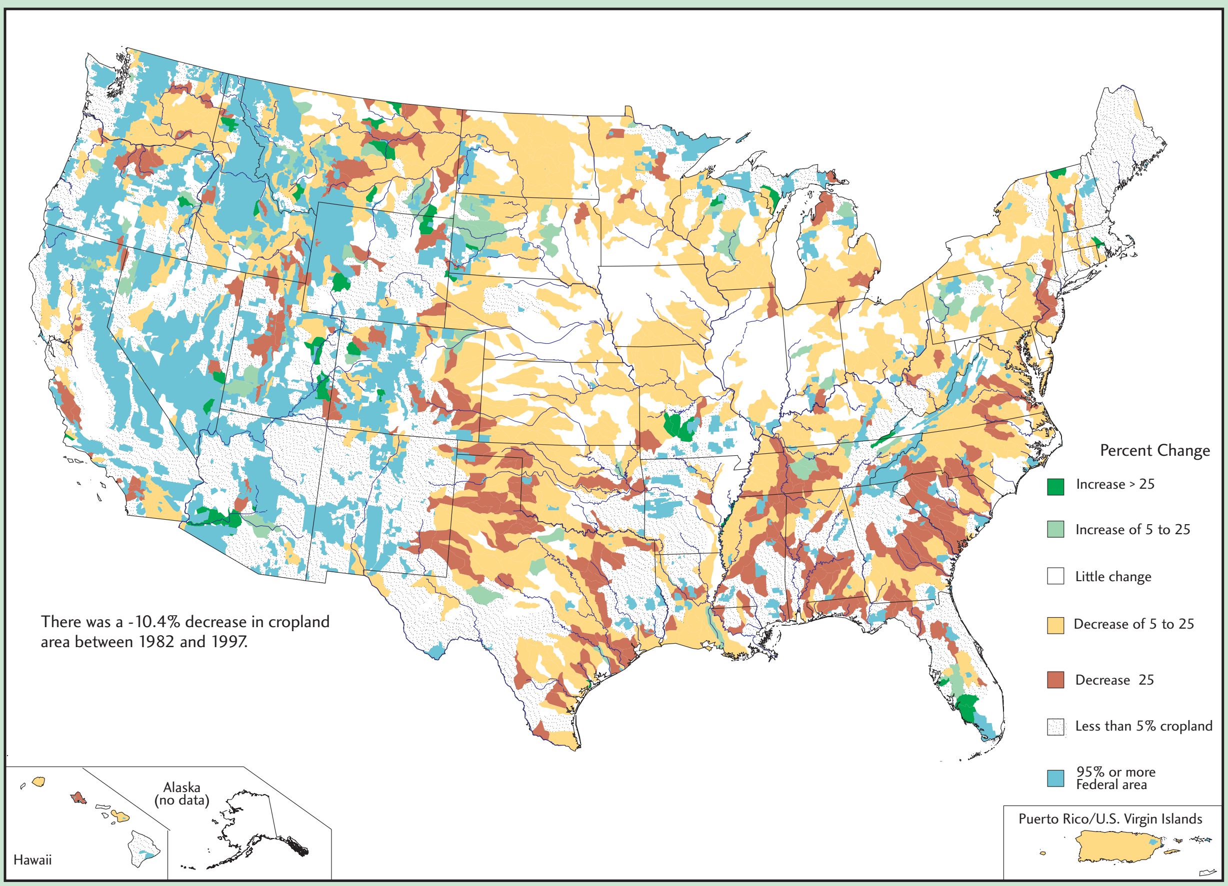
Data Sources

The data sources for this indicator are the National Resources Inventory, U.S. Department of Agriculture, Natural Resources Conservation Service, 1997 (Revised in December 2000); Summary Report: 1997 National Resources Inventory (Revised December 2000), U.S. Department of Agriculture, NRCS; and

Indicator Extent of agricultural land uses - Category 1 (continued)

Draft Environmental Impact Statement, U.S. Department of the Interior, Bureau of Land Management, 1994. The Heinz Center estimates of cropland acreages are derived from the National Land Cover Data, a product of the Multi-Resolution Land Characteristics Consortium, which is a partnership between the U.S. Geological Survey; the U.S. Department of Agriculture, Forest Service; the National Oceanographic and Atmospheric Administration; and the EPA. (See Appendix B, page B-19, for more information.)

Exhibit 3-8: Percent change in cropland area, 1982-1997



Source: USDA, Natural Resources Conservation Service. National Resources Inventory, 1997, revised December 2000: Percent Change in Cropland Area, 1982-1997. 2000. (January 2003; www.nrcs.usda.gov/technical/land/meta/m5874.html).

Indicator The farmland landscape - Category 2

Examining the broader context of agricultural lands can provide a better understanding of agricultural ecosystems. As previously noted, the Heinz report defined this term as not only the lands used to grow crops, but also the field borders, windbreaks, small woodlots, grassland and shrubland areas, wetlands, farmsteads, and small villages and other built-up areas within or adjacent to croplands. These covers/uses support not only agricultural production, but provide habitat for a variety of wildlife species as well.

What the Data Show

The farmland landscape indicator describes the degree to which croplands dominate the landscape and the extent to which other lands are intermingled (The Heinz Center, 2002).

Croplands comprise about half of the farmlands in the East and Southeast, while in the Midwest, almost three-quarters of the farmland ecosystem is cropland (The Heinz Center, 2002). Forests make up the remainder of the farmland ecosystem in the East, wetlands the remainder in the Southeast, and both forests and wetlands in the Midwest. In the West, about 60 percent of farmland ecosystem is cropland, with grasslands and shrublands dominating the remainder in the western and northern Plains areas. Forests and grasslands/shrublands are about equal in the farmland landscape for the non-cropland area of the South Central region. In many U.S. areas, other land cover types are almost as prevalent as croplands and can provide habitat for non-agronomic species.

Indicator Gaps and Limitations

This indicator uses satellite data from the early 1990s to describe the farmland landscape. Remote sensing technology can underestimate dispersed land development that is denser than scattered rural settlements, but not as dense as traditional "suburbs."

Data Source

The National Land Cover Database, with 21 land cover classes, was used to estimate the area coverage for the U.S. The NLCD is based on remotely sensed imagery from the Landsat 5 Thematic Mapper. Data are available from <www.usgs.gov/mrlcreg.html>. (See Appendix B, page B-19, for more information.)

3.1.3. What is the extent of grasslands and shrublands?

Indicator
Extent of grasslands and shrublands

Grasslands and shrublands can be viewed as one of the major ecological systems of the U.S. and are discussed in Chapter 5, Ecological Condition, (The Heinz Center, 2002). Grasslands and shrublands can be used for grazing and, in that sense, overlap in extent with agricultural land. As previously defined, pastureland and rangeland are covered by grass and shrub species. This ecosystem is one of the largest types in the U.S. and includes not only the grasslands and shrublands of the American West, but also coastal meadows, grasslands and shrubs in Florida, mountain meadows, hot and cold deserts, tundra, and similar areas in all states.

Indicator: Extent of grasslands and shrublands - Category 2

There was an estimated 900 million to 1 billion acres of grasslands and shrublands in the lower 48 states before European settlement (Klopatek, et al., 1979). By 1992, between 40 million and 140 million acres had been converted to other uses. Many pastures are managed in such a way that little of their original grassland character remains, however. Thus, the area of relatively unmanaged grasslands and shrublands has probably declined more than the overall figures would indicate (The Heinz Center, 2002). One factor in the decline of grassland pasture and range acreages since the 1960s is that forage productivity has increased and the number of domestic animals has declined (Vesterby, 2003).

What the Data Show

Based on remote sensing satellite data, it is estimated that grasslands and shrublands (including pasturelands and haylands) occupy about 861 million acres in the lower 48 states and 205 million acres in Alaska, for a total of 1.066 billion acres or about 47 percent of the U.S. (not including Hawaii) (The Heinz Center, 2002) (Exhibit 3-9). This estimate distinguishes 178 million acres of pasturelands and haylands, which are also considered to be part of the farmland landscape, leaving 683 million acres of grasslands and shrublands in the lower 48 states (The Heinz Center, 2002).

Indicator Gaps and Limitations

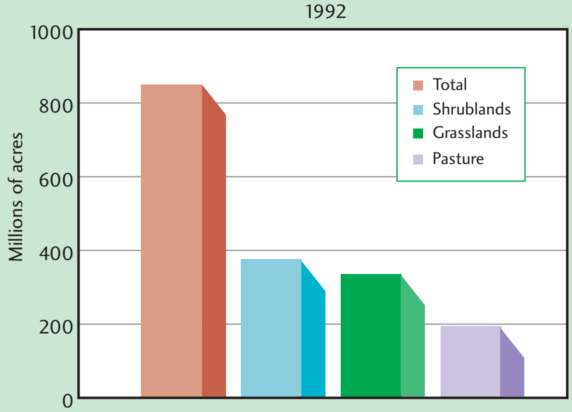
NLCD was used to estimate extent of grasslands and shrublands in the lower 48 states. Other data were estimated for Alaska. This is a complicated and changing ecosystem that is subject to conversion to other uses. It would be useful to have better means to characterize and track extent.

Data Sources

The National Land Cover Database with 21 land cover classes, was used to estimate the area coverage for the U.S. The NLCD is based on remotely sensed imagery from the Landsat 5 Thematic Mapper. Data are available from <www.usgs.gov/mrlcreg.html>. Data for Alaska were estimated from a vegetation map of Alaska by Flemming (1996), based on Advanced Very High Resolution Radiometer remote sensing images with an approximate resolution of 1 kilometer on a side (The Heinz Center, 2002). (See Appendix B, page B-19, for more information.)

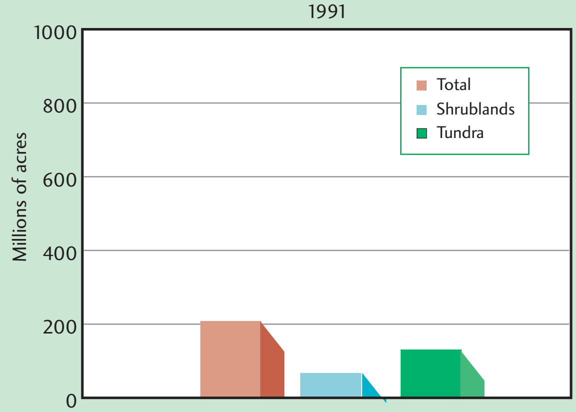
Exhibit 3-9: Extent of grasslands and shrublands, 1991 and 1992

Area of grasslands and shrublands, lower 48 states
1992



Source: EPA, Office of Research and Development. Multi-Resolution Land Characteristics Consortium, National Land Cover Data. 1992. (February 19, 2003; *http://www.epa.gov/mrlc/nlcd.html*).

Area of grasslands and shrublands, Alaska
1991



Source: Flemming, M.D. *A Statewide Vegetation Map of Alaska Using a Phenological Classification of AVHRR Data.* February 1996.

3.1.4 What is the extent of forest lands?

Indicator

Extent of forest area, ownership, and management

Forests provide a range of important benefits to society. In addition to providing wood products, such as paper and lumber, forest lands help to purify air and water, mitigate floods and droughts, regulate climate through storage of carbon dioxide, regenerate soils, provide habitat for fish and wildlife, and support recreational opportunities. Trends in the extent of forests are an important indicator of human management of the landscape, since forest lands cover about one-third of the total U.S. land area. This section provides information on the status and trends relating to the amount and management of forest land. Additional information on the condition of forest land is found in Chapter 5, Ecological Condition.

Indicator Extent of forest area, ownership, and management - Category I

It is estimated that in 1630, 1.045 billion acres of forest land existed in what would become the U.S. land area. (USDA, FS, 2001). Nearly 25 percent of these lands were cleared by the early 1900s, leaving 759 million acres in 1907. Since that time the total amount of forest land nationwide, while changing regionally has remained relatively stable, with an increase of 2 million acres between 1997 and 2001.

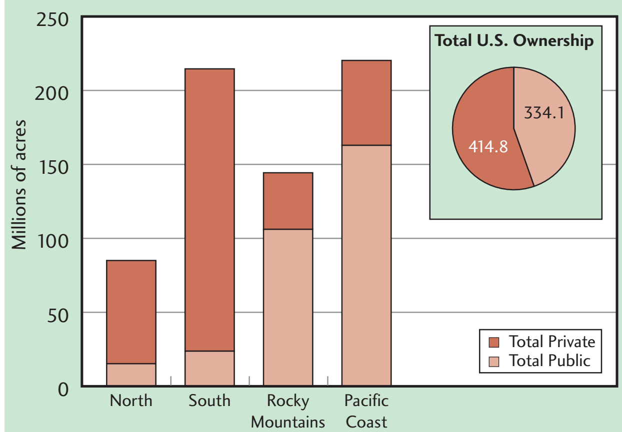
What the Data Show

There were an estimated 749 million acres of forest land in the U.S. in 2001 (USDA, FS, 2002). In the period between 1987 and 2001, forest land acreage increased by about 11 million acres (USDA, FS, 2002).

There have been regional changes in the amount of forest land due to changing patterns of agriculture, development, and reversion to forests. Since the 1950s, forest lands in the northeast and northcentral states have increased by almost 10 million acres, while the South has lost about 11 million acres (USDA, FS, 2001). Private forest lands are being converted to developed land uses faster than any other land type (USDA, NRCS, 2001).

Forest land management varies greatly depending on differences in ownership, management intent, and desired outcomes, ranging from lands managed intact to protect water supplies, to harvesting for timber production. About 55 percent of the nation's forest lands are in private ownership (USDA, FS, 2002). Most forest lands are managed for a mix of uses, such as recreation, timber harvest, grazing, and mining. In the southern and eastern U.S., most forest land is privately held in relatively small holdings, while in the Rocky Mountains and western U.S., most forest lan d is in large blocks of public ownership in national forests (Exhibit 3-10). As previously noted, ownership affects how lands are managed and used.

Exhibit 3-10: Forest land ownership by region, 2001



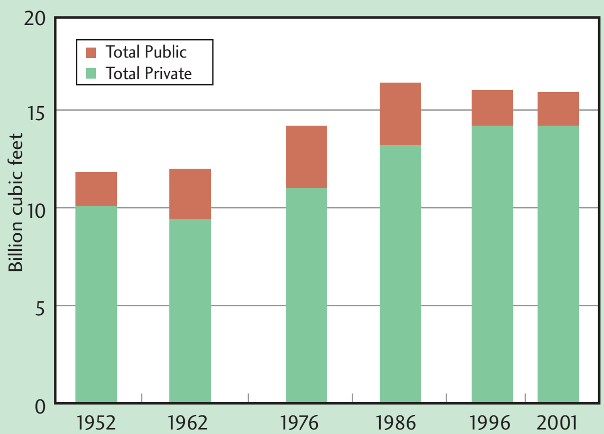
Source: USDA, U. S. Forest Service. Draft Resource Planning Act Assessment Tables. May 3, 2002 (updated August 12, 2002). (September 2003; *http://www.ncrs.fs.fed.us/4801/FIADB/rpa_tabler/Draft_RPA_2002_Forest_Resource_Tables.pdf*).

About 76 million acres, or 10 percent of the nation's forests are "reserved" and managed as national parks or wilderness areas (USDA, FS, 2002). These estimates of reserves include state and federal parks and wilderness areas, but do not include conservation easements, areas protected by non-governmental organizations, or most urban and community parks and reserves. There are significant regional differences in the amount of forest reserves. In the West, reserves are common, comprising nearly 18 percent of the total forest area. Much of the protected forest in the West is in stands over 100 years old. Only 3 percent of eastern forests are in reserves such as parks and wilderness (USDA, FS, 2001).

Indicator | Extent of forest area, ownership, and management - Category I (continued)

About 66 million acres, or 9 percent of forest lands, are managed by private forest industries to produce timber (USDA, FS, 2002). Much of the remaining forest land receives less intensive management activity, such as periodic harvest of mature timber. Approximately 503 million acres of public and private forest land are currently classified as timberlands by the USDA Forest Service, an increase of 17 million acres since 1987 (USDA, FS, 2002). Approximately 63 percent of all U.S. timber harvesting is conducted in the South, predominately from private lands. Total timber harvest increased substantially between 1976 and 2001 in the East. In the West, after increasing steadily from 1952 to 1986, timber harvesting on public lands has declined sharply. Public lands harvested nationwide dropped nearly 47 percent from 1976 to 2001, to less than 2 billion cubic feet per year. In the same time frame, private lands harvested increased by about 29 percent, from 11 to 14 billion cubic feet annually. (USDA, FS, 2002) (Exhibit 3-11).

Exhibit 3-11: Timber removals in the United States by owner group, 1952-2001



Source: USDA, U. S. Forest Service. Draft Resource Planning Act Assessment Tables. May 3, 2002 (updated August 12, 2002). (September 2003; *http://www.ncrs.fs.fed.us/4801/FIADB/rpa_tabler/Draft_RPA_2002_Forest_Resource_Tables.pdf*).

Between 1980 and 1990, approximately 10 million acres were harvested annually. Of the public and private forest lands harvested for timber approximately 62 percent are selectively cut, while 38 percent are clearcut. Most of the clearcutting occurs in the South (USDA, FS, 2001).

Indicator Gaps and Limitations

Limitations for this indicator include the following:

- The data for this indicator were collected by the USFS FIA program. Forest Industry and Analysis (FIA) currently provides updates of assessment data every five years. Field data are collected on a probability sample of 125,000 forested sites and extended to a remote sensing database on 450,000 sites by the FIA program (Smith, et al., 2001). The resulting data on extent have an uncertainty of 3 to 10 percent per million acres for data reported since 1953. Regional estimates have errors of less than two percent (The Heinz Center, 2002).
- The FIA data on reserved lands do not include information on private lands that are legally reserved from harvest, such as lands held by private groups for conservation purposes. In addition, other forest lands are at times reserved from harvest because of administrative or other restrictions.

Data Source

The data for this indicator are from the *Draft Resource Planning and Assessment Tables*, U.S. Department of Agriculture, Forest Service, 2002. (See Appendix B, page B-20, for more information.)

USDA Forest Service Definitions

Forest land. Land that is at least 10 percent stocked by forest trees of any size, including land that formerly had tree cover and that will be naturally or artificially regenerated. The minimum area for classification of forest land is 1 acre.

Timber land. Forest land that is capable of producing crops of industrial wood (at least 20 cubic feet per acre per year in natural stands) and not withdrawn from timber utilization by statute or administrative regulation.

Reserved forest land. Forest land withdrawn from timber utilization through statute, administrative regulation, or designation. (USDA, FS, April 2001)

3.1.5 What human health effects are associated with land use?

Land development patterns have direct and indirect effects on air and water quality, which can then affect human health. For example, the increased concentration of air pollutants in developed areas can exacerbate human health problems like asthma. Increased storm water runoff from impervious surfaces threatens the waterbodies that urban and suburban residents rely on for drinking and recreation. Development patterns can affect quality of life by limiting recreational opportunities, decreasing open space, and increasing vehicle miles traveled and the amount of time spent on roads. Also, as discussed later, agricultural land uses may expose humans to dust and various chemicals. No specific indicators have been identified at this time.

Land use also can have indirect effects on air quality. Low-density patterns of development can often increase commutes—more people drive more miles. "Heat islands," or domes of warmer air over urban and suburban areas, are caused by the loss of trees and shrubs and the absorption of more heat by pavement, buildings, and other sources. Heat islands can affect local, regional, and global climate, as well as air quality. Agricultural land uses also result in increased wind erosion. Degraded air quality can contribute to human health issues such as asthma. Additional discussion of the effects of land uses on air and water quality, human health, and the environment is included in other chapters.

3.1.6 What ecological effects are associated with land use?

Indicator
Sediment runoff potential from croplands and pasturelands

Land use and land management practices change the landscape in many ways that have both direct and indirect ecological effects. One direct effect is the loss or conversion of acres of certain cover or ecosystem types to other more human-oriented land uses such as developed and agricultural uses. Indirect effects may include changes in runoff patterns or increased soil erosion.

The 25 million acre increase in developed land that occurred between 1982 and 1997 came about through the conversion of about 10 million acres of forest land, 7 million acres of agricultural land, 4 million acres of pastureland, 4 million acres of rangeland, and 1 million acres of various other land cover types including wetlands (USDA, NRCS, 1997). The causes of wetland loss are detailed in Chapter 2, Purer Water. Changing land use patterns have also affected the extent and location of agricultural land. Between 1982 and 1997, approximately 13.6 million acres were converted from cropland to other uses, including 7.1 million acres converted to developed land. At the same time, approximately 4 million acres of rangeland were converted to more intensive crop uses (USDA, NRCS, 2000a). The conversions of land from agricultural, forest land, and rangeland cover types to developed land can affect different species in specific locations that depend on those cover types for habitat and food. Species effects in various ecosystems are discussed in more detail in Chapter 5, Ecological Condition.

Land development also creates impervious surfaces through construction of roads, parking lots, and other structures. Impervious surfaces contribute to non-point source water pollution by limiting the capacity of soils to filter runoff. Impervious surface areas also affect peak flow and water volume, which heighten erosion potential and affect habitat and water quality (e.g., temperature increases). They also affect ground water aquifer recharge. With sufficient storm water infrastructure, higher population density in concentrated areas can reduce water quality impacts from impervious surfaces by accommodating more people and more housing units on less land and developing water runoff systems that address issues of pollutants and sediment. Impervious surfaces developed as the result of suburban or dispersed development patterns are more difficult to mitigate, given that the effects are more dispersed and development of runoff infrastructure is costly.

Storm runoff from urban and suburban areas contains dirt, oils from road surfaces, nutrients from fertilizers, and various toxic compounds. Point source discharges from industrial and municipal wastewater treatment facilities can contribute toxic compounds and heated water. Directing water through channels alters hydrologic flow patterns. Increases in siltation and temperature can make stream habitats unsuitable for native microinvertebrate and fish species. Changes in the nutrient and chemical composition of stream water can encourage growth of toxic algae and harmful organisms. The types of crops planted, tillage practices, and various irrigation practices can limit the amount of water available for other uses, such as municipal, industrial, and natural ecosystems. Livestock grazing in riparian zones also can change landscape conditions by reducing stream bank vegetation and increasing water temperatures, sedimentation, and nutrient levels. Runoff from pesticides, fertilizers, and nutrients from animal manure can also degrade water quality.

An indirect ecological effect of land use is the introduction of invasive species. Certain land use practices, such as overgrazing, land conversion, fertilization, and the use of agricultural chemicals can enhance the growth of invasive plants. Other human activities can result in unstable or disturbed environments and encourage the establishment of invasive plants. These activities include farming; creating highway and utility rights-of-way; clearing land for homes and recreation areas such as golf courses; and constructing ponds, reservoirs, and lakes (Westbrooks, 1998). Failure to manage invasive species can lead to a major threat to native ecosystems. Non-native species can alter fish and wildlife habitat, contribute to decreases in biodiversity, and create health risks to livestock and humans. Introduction of invasive species on agricultural lands also can reduce water quality and water availability for native fish and wildlife species; clog lakes, waterways, and wetlands; weaken the ecosystem; and adversely affect water treatment facilities and public water supplies. Agricultural uses also can encourage the growth of invasive species (USFWS, 2002).

Land practices related to development, timber harvest, and agriculture can affect soil quality both positively and negatively. Some agricultural practices encourage soil conservation, minimizing effects on soil resources. These practices include organic farming; creating buffer strips in riparian zones; tree planting for windbreaks or to decrease water temperature to improve fish habitat; soil erosion control; integrated pest management; and precision pesticide and fertilizer application technology. In contrast, other agricultural activities promote soil compaction or result in loss of topsoil through soil erosion. The indicator identified for this question addresses the potential for sediment to run off from croplands and pasturelands.

Indicator: Sediment runoff potential from croplands and pasturelands - Category 2

Soil erosion and transport can occur both by wind and by water and have several major effects on ecosystems. Sediment is the greatest pollutant in aquatic ecosystems—both by mass and volume—and soil erosion and transport are the source (EPA, OW, August 2002). Soil particles also can transport nutrients and pesticides into aquatic systems where they may degrade water quality. Although rates of erosion declined between 1982 and 1997 by about 1.4 tons/acre, more than one-quarter of all croplands still suffer excessive wind and water erosion (USDA, NRCS, 2000f). Excessive is defined as exceeding tolerable rates as defined by USDA NRCS models (USDA, NRCS, 2000g).

Agricultural soil erosion decreases soil quality and can reduce soil fertility, and soil movement can make normal cropping practices difficult (The Heinz Center, 2002). The loss of productive top soil and organic matter affects the productivity of agricultural lands. Further discussion on the extent and effects of soil erosion can be found in Chapter 2, Purer Water, and in Chapter 5, Ecological Condition.

What the Data Show

The potential for soil erosion and sediment runoff varies depending on specific land use, rainfall amounts and intensity, soil characteristics, landscape characteristics, cropping patterns, and farm management practices. This indicator is the result of analyses conducted by combining land cover, weather patterns, and soil information in a process model that incorporates hydrologic cycling, weather, sedimentation, crop growth, pesticide and nutrient loading, and agricultural management to estimate the amount of sediment that could potentially be delivered to rivers and streams in each watershed. The simulation estimated sheet and rill erosion using a process model known as the Soil and Water Assessment Tool (SWAT). SWAT is a model that is supported by the USDA Agricultural Research Service. The sediment runoff data have been categorized and are presented as low, medium, and high potential for runoff.

Exhibit 3-12 displays the distribution of watersheds (based on 8-digit hydrologic unit codes [HUCs]) nationwide and the potential for sediment runoff (or delivery to rivers and streams) from croplands and pasturelands. The highest potential for sediment runoff is concentrated in the central U.S., predominately associated with the upper Mississippi River Valley and the Ohio River Valley. Most of the western U.S. is characterized by low runoff potential (lower percentage of cropland and pastureland).

Indicator Gaps and Limitations

This indicator has several limitations for:

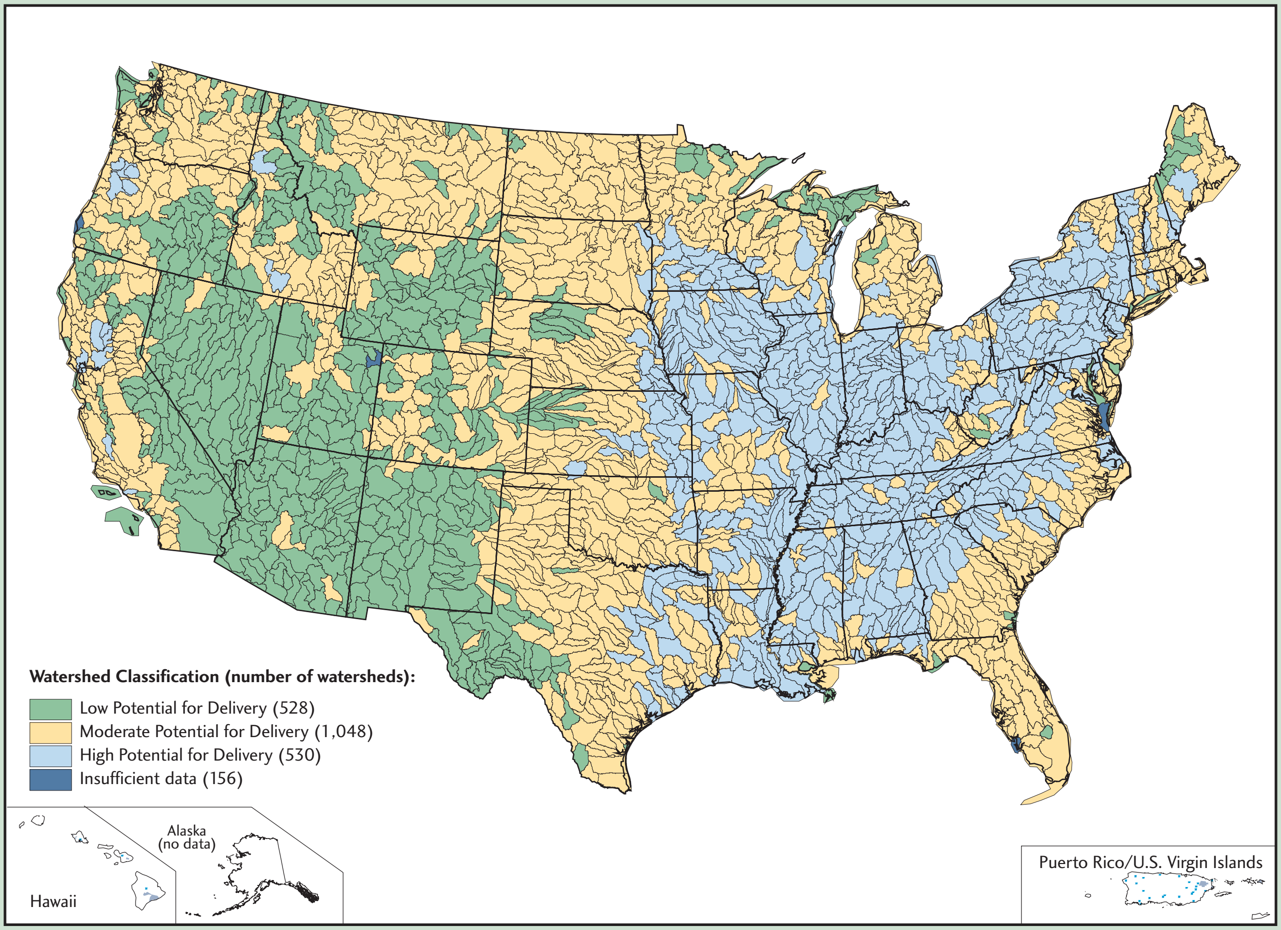
- Sediment loads from non-agricultural land uses are not included in these estimates.
- Estimates represent potential loadings to rivers and streams, and do not represent in-stream loads.
- Gully erosion and channel erosion are not included.

Data Source

The Soil and Water Assessment Tool is a public domain model actively supported by the U.S. Department of Agriculture, Agricultural Research Service at the Grassland, Soil and Water Research Laboratory in Temple, Texas (see http://www.brc.tamus.edu/swat/).
(See also Appendix B, page B-22, for more information.)

Indicator Sediment runoff potential from croplands and pasturelands - Category 2 (continued)

Exhibit 3-12: Sediment runoff potential from croplands and pasturelands, 1990-1995



Source: Walker, C. Sediment Runoff Potential, 1990-1995. August 24, 1999. (September, 2002; *http://www.epa.gov/iwi/1999sept/iv12c_usmap.html*).

3.2 Chemicals in the Landscape

This section focuses on the extent, potential disposition, and effects of chemicals used or managed on land. The production and use of chemicals in the U.S. has increased over the last 50 years. The use and release of chemicals can have various effects on human health and ecological condition. Commercial and industrial processes such as mining, manufacturing, and the generation of electricity all use and release chemicals. Chemicals that control weeds, insects, rodents, fungi, bacteria, and other organisms are called pesticides and are commonly used on agricultural lands, as well as in urban, industrial, and residential settings. Fertilizers—supplements to improve plant growth—are also used extensively in a variety of settings. Pesticides and fertilizers have contributed to high agricultural productivity levels in the U.S.

EPA began monitoring the production and importation of industrial chemicals in 1977 through the Toxics Substances Control Act Chemical Inventory, which presently identifies more than 76,000 chemicals used in U.S. commerce. Nearly 10,000 of these chemicals are produced or imported in quantities greater than 10,000 pounds per year (excluding inorganics, polymers, microorganisms, naturally occurring substances, and non-isolated intermediaries). About 3,100 of these chemicals are produced or imported in quantities exceeding 1 million pounds per year. Associated annual production/import volumes increased by 570 billion pounds (9.3 percent) to 6.7 trillion pounds between 1990 and 1998 (EPA, OPPTS, 2002).

The questions posed in this section consider the amounts and types of chemicals released to the landscape, addressing toxic substances, pesticides, and fertilizers. The discussion also looks at the potential for chemicals to move from their use on land to places where humans and other organisms can be exposed to them. In this context, questions also address what is currently known about health and ecological effects from exposure to chemicals used on land.

The six questions considered in this section are:

- How much and what types of toxic substances are released into the environment?
- What is the volume, distribution, and extent of pesticide use?
- What is the volume, distribution, and extent of fertilizer use?
- What is the potential disposition of chemicals from land?
- What human health effects are associated with pesticides, fertilizers, and toxic substances?
- What ecological effects are associated with pesticides, fertilizers, and toxic substances?

The primary sources of data for this section are the EPA Toxics Release Inventory (TRI), describing quantities of toxic chemical releases; pesticide use estimates (based on sales) from both EPA and the non-profit National Center for Food and Agricultural Policy (NCFAP); data from the USDA's *Agricultural Resources and Environmental Indicators* report published in 2000 on the volume, distribution, and extent of fertilizer use (see Appendix B); and data from the USDA Pesticide Data Program on pesticide residues found on food samples.

3.2.1 How much and what types of toxic substances are released into the environment?

Indicator

Quantity and type of toxic chemicals released and managed

Many industries release toxic substances into the air, soil, and water through their manufacturing and production activities. Under the Emergency Planning and Community Right-to-Know Act of 1986 and the Pollution Prevention Act of 1990, most facilities are required to calculate and report to EPA and states their release and other waste management quantities of more than 650 toxic chemicals and chemical categories. Intended uses of this information include helping communities prepare for chemical spills and similar emergencies and educating the public on industries' release and other waste management practices for toxic chemicals. EPA makes these toxic release data available to the public annually via the *Toxics Release Inventory* (TRI) *Public Data Release Report*.

The indicator identified for this question addresses quantity and type of toxic chemicals released and managed as waste as well as trends.

Indicator Quantity and type of toxic chemicals released and managed - Category 2

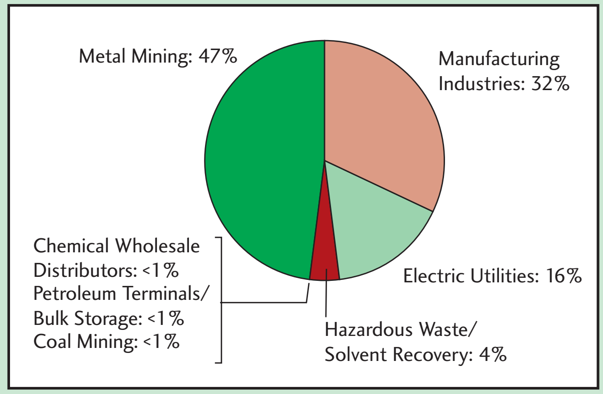
The data collected in TRI represent only part of a broader universe of chemicals used and released into the environment. TRI includes a large amount of information on a range of categories of toxic chemicals, including many arsenic, cyanide, dioxin, lead, mercury, and nitrate compounds and provides information on the amount and trends in releases and management of chemicals, including recycling, recovery, and treatment. TRI data cover releases from reporting facilities in all parts of the country and can be searched for releases within individual zip codes. All data presented below can be found in the *EPA 2000 Toxics Release Inventory Public Data Release Report* (EPA, OEI, May 2002).

What the Data Show

Releases to the environment for all EPA-tracked TRI chemicals from nearly 23,500 facilities totaled 7 billion pounds in 2000. Of these releases, 58 percent were to land, 27 percent were to air, 4 percent each were to water and underground injection at the generating facility, and 7 percent were chemicals disposed of off-site to land or underground injection. Three industries accounted for most of the releases: metal mining (27 facilities) accounted for 47 percent, manufacturing industries (21,352 facilities) for 32 percent, and electric utilities (706 facilities) for 16 percent. The remaining 5 percent was split among hazardous waste/solvent recovery, coal mining, petroleum terminals/bulk storage, and chemical wholesale distributors (Exhibit 3- 13).

Exhibit 3-13: Total toxic release inventory (TRI) releases by industry, 2000

(Total = 7 billion pounds)



Source: EPA, Office of Environmental Information. *2000 Toxics Release Inventory (TRI) Public Data Release Report.* May 2002.

Between 1998 and 2000, the total amount of toxic releases as estimated by the TRI decreased by approximately 409 million pounds, or 5.5 percent. Of that total, releases to land decreased approximately 276 million pounds. Decreases in the releases by certain industries (e.g., manufacturing and metal mining) account for most of the overall decrease between 1998 and 2000. A few industries (e.g., hazardous waste/solvent recovery, coal mining, and chemical wholesale distributors) increased their releases during this time period. Off-site releases from production increased by 75 million pounds in the 1998 to 2000 time frame (Exhibit 3-14).

Exhibit 3-14: Toxics release inventory (TRI) total releases and change by industry, 1998-2000

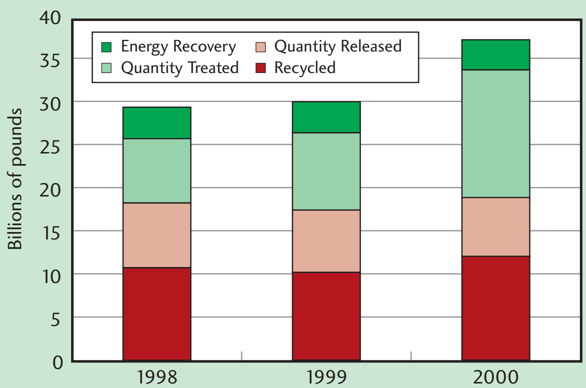
Source: EPA, Office of Environmental Information. *2000 Toxics Release Inventory (TRI) Public Data Release Report.* May 2002.

Indicator: Quantity and type of toxic chemicals released and managed - Category 2 (continued)

The seven billion pounds of chemicals actually released into the environment (air, water, and land) are a subset of toxic chemicals managed and tracked in TRI. Another 31 billion pounds of toxic chemicals were managed as waste in 2000. Nearly all (>99 percent) of these toxic chemicals were production related, Of the 31 billion pounds, 50 percent was treated, 39 percent was recycled, and 11 percent was burned for energy recovery.

The total amount of toxic chemicals managed as waste during the three-year period of 1998 to 2000 increased by almost 29 percent, a net increase of 8.4 billion pounds (Exhibit 3-15). Two industries in the southeastern U.S., printing/publishing and chemicals and allied products, accounted for most of this increase. Between 1998 and 2000, the chemicals recycled increased by more than 12 percent (1.3 billion pounds). In contrast, the quantities of chemicals combusted for energy recovery decreased 4.1 percent.

Exhibit 3-15: Trends in toxic chemicals 1998-2000



Note: The data shown as "Quantity Released" vary from the data in Exhibit 3-14 because some facilities include off-site transfers for disposal to other TRI facilities that then report the amount as on-site release.

Source: EPA, Office of Environmental Information. *2000 Toxics Release Inventory (TRI) Public Data Release Report.* May 2002.

The TRI data are also used to support EPA's National Waste Minimization Partnership Program, which focuses on reducing or eliminating the generation of hazardous waste containing any of 30 Waste Minimization Priority Chemicals (WMPC). These chemicals are found in hazardous waste and are documented contaminants of air, land, water, plants and animals. EPA has tracked 17 of these chemicals since 1991 and reports that WMPC generation quantities have been steadily declining since 1993 (Exhibit 3-16). Overall, between 1991 and 1998, the generation of WMPC in industrial hazardous and solid waste decreased by 44 percent.

Indicator Gaps and Limitations

The TRI data do not reflect a comprehensive total of toxic releases nationwide. Although EPA has added to the number of industries (SIC codes) that must report, the TRI program does not cover all releases of chemicals from all industries. Second, industries are not required to report the release of several types of toxic chemicals, because these chemicals are not included in the TRI list. Third, facilities that do not meet the TRI reporting requirements (those with fewer than 10 full-time employees or the

Waste Minimization Priority Chemicals

Organic chemicals and chemical compounds:

*1,2,4-Trichlorobenzene
1,2,4,5-Tetrachlorobenzene
*2,4,5-Trichlorophenol
4-Bromophenyl phenyl ether
Acenaphthene
Acenaphthylene
*Anthracene
Benzo(g,h,i)perylene
*Dibenzofuran
Dioxins/Furans (considered one chemical on this list)
Endosulfan, alpha & Endosulfan, beta (considered one chemical on this list)
Fluorene
*Heptachlor & Heptachlor epoxide (considered one chemical on this list)
*Hexachlorobenzene
*Hexachlorobutadiene
*Hexachlorocyclohexane, gamma-
*Hexachloroethane
*Methoxychlor
*Naphthalene
PAH Group (as defined in TRI)
Pendimethalin
Pentachlorobenzene
*Pentachloronitrobenzene
*Pentachlorophenol
Phenanthrene
Pyrene
*Trifluralin

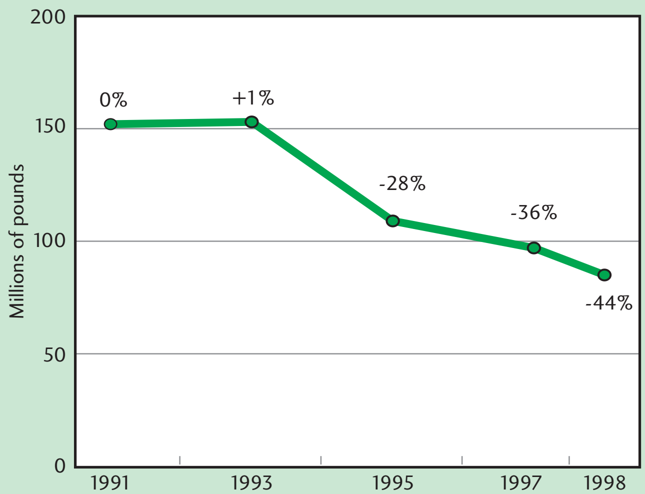
Metal and Metal Compounds:

*Cadmium
*Lead
*Mercury

(*17 chemicals tracked since 1991)

Indicator Quantity and type of toxic chemicals released and managed - Category 2 (continued)

Exhibit 3-16: Trends in toxics release inventory (TRI) Waste Minimization Priority Chemicals (WMPC), 1991-1998



Source: EPA, Office of Solid Waste and Emergency Response. *Waste Minimization Trends Report (1991-1998)*. September 2002.

employee equivalent, or those not meeting TRI chemical-specific reporting threshold amounts) are not required to report their releases and therefore are not included as part of the total. Finally, facilities report their release and other waste management data to TRI using monitoring data, emission factors, mass balance approaches and engineering calculations. EPA does not mandate monitoring of releases, although many industries do conduct monitoring. Various estimation techniques are used when monitoring data are not available. EPA has published estimation guidance for the regulated community, but not all industrial facilities use consistent estimation methodologies, and variations in reporting may result. With approximately 76,000 different types of chemicals in existence, and new ones constantly being developed, the challenge is to ensure that those that are likely to pose the greatest hazards are tracked and managed.

Data Source

The data source for this indicator is EPA, Toxics Release Inventory, 2000. (See Appendix B, page B-20, for more information.)

3.2.2 What is the volume, distribution, and extent of pesticide use?

Indicator
Agricultural pesticide Use

Pesticides are substances or mixtures of substances intended for preventing, destroying, repelling, or mitigating plant or animal pests. Conventional pesticides include herbicides, plant growth regulators, insecticides, fungicides, nematicides, fumigants, rodenticides, molluscicides, aquatic pesticides, and fish/bird pesticides. Most pesticides create some risk of harm to humans, animals, or the environment because they are designed to kill or otherwise adversely affect living organisms. At the same time, pesticides are useful to society because of their ability to kill potential disease-causing organisms and control insects, weeds, and other pests.

Currently, no reporting system provides information on the volume, distribution, and extent of pesticide use nationwide across all sectors. Estimates, however, of total pesticide use have been developed based on available information such as crop profiles, pesticide sales, and expert surveys. Several of these data sets are collected by the private or non-profit sectors rather than federal agencies.

EPA's recent *Pesticide Industry Sales and Usage Report* estimates show that conventional annual pesticide use declined by about 15 percent between 1980 and 1999. This change has not been steady; in 1999, pesticide use was higher than it was in the early 1990s. Of the three sectors of pesticide use assessed in EPA estimates (agricultural, industry-commercial-government, and home-garden), the industrial-commercial-government use of pesticides has seen the most steady decline over this 20-year period. EPA estimates show that in 1999, agricultural pesticide use accounted for nearly 77 percent (956 million pounds) of all pesticide use; home and garden use was 11 percent (140 million pounds); and industrial, commercial, and government use was nearly 12 percent (148 million pounds) of total conventional pesticide use (1244 million pounds). These estimates do not include wood preservatives, biocides, and chlorine/hypochlorites (EPA, OPPTS, 2002).

An important class of pesticides—insecticides—has undergone significant use reduction in the last 5 years. Insecticides, as a class, tend to be the most acutely toxic pesticides to humans and wildlife. The number of individual chemical treatments per acre, referred to as "acre-treatments," for insecticides labeled "danger for humans" has undergone a 43 percent reduction in use from 1997 to 2001. Over the same period, acre-treatments for insecticides labeled "extremely or highly toxic to birds" have been reduced by 50 percent, and insecticides labeled "extremely or highly toxic to aquatic organisms" have been reduced by 23 percent (EPA, OPP, 2001). The indicator identified for this question specifically addresses agricultural pesticide use.

Indicator

Agricultural pesticide use - Category 2

Building on EPA and USDA estimates, as well as on pesticide use surveys, the National Center for Food and Agricultural Policy (NCFAP), a private, non-profit, research organization, has established a pesticide use database that provides estimates of agricultural pesticide use by chemical, crop, and state.

What the Data Show

According to NCFAP, and as shown in Exhibit 3-17, total agricultural pesticide use increased from 892 to 985 million pounds between 1992 and 1997. (EPA reports a similar increase in use of all pesticides in this same time frame, and a leveling of use between 1997 and 1999.) (EPA, OPPTS, 2002). Approximately half of these agricultural pesticides are herbicides used to control weeds that limit or inhibit the growth of the desired crop. While many pesticides are synthetic chemicals, some biopesticides, such as *Bacillus thuringiensis,* are also broadly used and are key components of organic farming programs.

The 1997 NCFAP summary report shows that more pesticides are used on corn than on any other crop. At the same time, corn is planted on more acres than any other single crop. It is also most effectively treated with a combination of chemicals that are applied in high quantities per acre.

Oil, most often applied as a spray, is used in greater quantities than any other pesticide across all crops. In the context of the NCFAP report, "oil" includes plant oil extracts with insecticidal properties, vegetable oils that work by smothering pests, and petroleum derivatives used as solvents and insecticides. Sulfur—through its broad applicability as an insecticide, fungicide, and rodenticide—and atrazine, largely due to its use with corn, are the next two most commonly used chemicals.

Indicator Gaps and Limitations

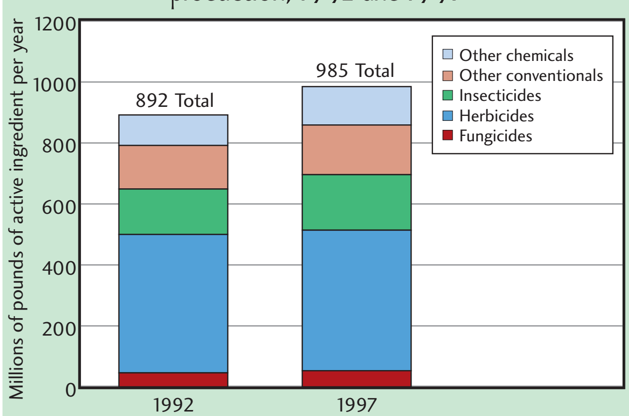
Limitations for this indicator include the following:

- The data quality of the NCFAP national pesticide use database is unknown. The database is not a direct record based on reports of actual usage and application. Some of the database estimates are derived from surveys of farmers, and others are expert opinions from knowledgeable extension service specialists. Also, because of the absence of data for many states and crops, many records have been assigned based on the data from a nearby state. It is unclear how accurate these sources and procedures are. The 1997 summary report for the database carefully makes no claims to statistical accuracy because of the variety of sources and techniques for estimation of chemical usage. Several federal agencies, however, use the information, and NCFAP has received funding from USDA to update the pesticide use database for 2002 (Gianessi and Marcelli, 2000).
- NCFAP data only report on the agricultural use of pesticides, which leaves out other commercial non-agricultural and residential applications. Additional data would be advantageous for tracking these uses of pesticides.

Data Source

The data source for this indicator is the National Center for Food and Agricultural Policy's Pesticide Use Database, 2000. (See Appendix B, page B-21, for more information.)

Exhibit 3-17: Pesticide use in crop production, 1992 and 1997



Source: Gianessi, L.P., and M.B. Marcelli. *Pesticide Use in U.S. Crop Production: 1997, National Summary Report.* November 2000.

3.2.3 What is the volume, distribution, and extent of fertilizer use?

Indicator
Fertilizer use

Fertilizers have contributed to an increase in commercial agricultural productivity in the U.S. throughout the latter half of the 20th century. Using fertilizers and soil amendments, farmers have successfully enhanced the productivity of marginal soils and shortened recovery times for damaged areas. Similar to pesticide use, however, the increasing use of commercial fertilizers in agriculture has consequences for human health and ecological condition. Between World War II and the early 1980s, commercial fertilizer use increased consistently and significantly (Battaglin and Goolsby, 1994). Fertilizer use patterns today are greatly influenced by crop patterns, economic and climatic factors, and crop reduction programs implemented by local and federal government agencies (Council on Environmental Quality, 1993). The indicator identified for this question specifically addresses the volume, distribution, and extent of fertilizer use.

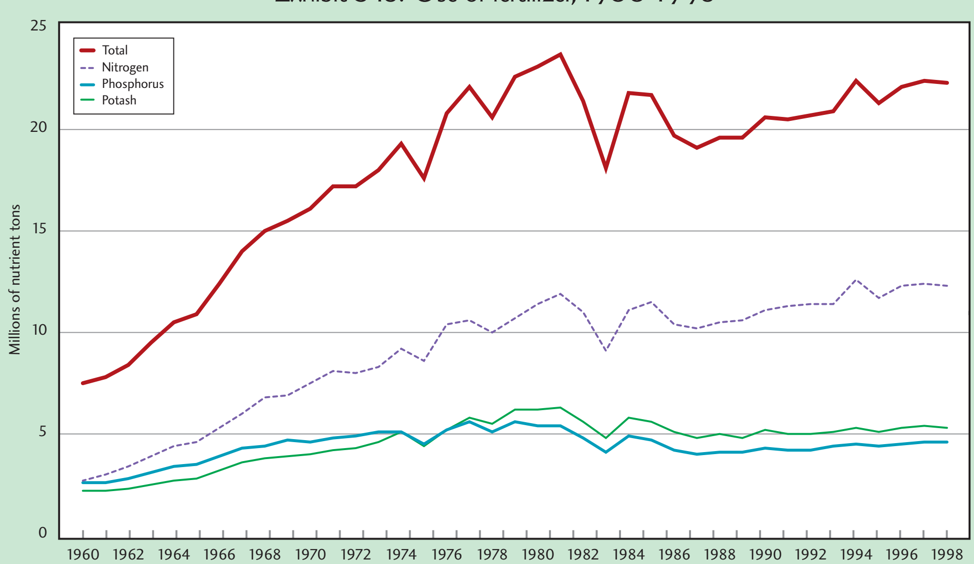
Indicator — Fertilizer use - Category 2

Most data on the volume and distribution of fertilizer use are based on sales data collected by USDA. Usage is concentrated heavily in the midwestern states where agricultural production—particularly that of corn—is greatest.

What the Data Show

According to the *2000 USDA Agricultural Resources and Environmental Indicators Report,* the use of nitrogen, phosphorus, and potash—the most prevalent supplements used in fertilizers for commercial farming—rose from 7.5 million nutrient tons in 1961 to 23.7 million tons in 1981. Although aggregate use dipped in 1983, it increased most recently between 1996 and 1998 to more than 22 million nutrient tons (Daberkow, et al, 2003) (Exhibit 3-18).

Exhibit 3-18: Use of fertilizer, 1960-1998



Source: Daberkow, et al. *Agricultural Resources and Environmental Indicators: Nutrient Use and Management.* February 2003.

Indicator Gaps and Limitations

Several limitations are associated with this indicator:

- The data that do exist are based primarily on sales information and use estimates. Gross sales data are not necessarily a reflection of fertilizer usage, nor do they convey any information about the efficiency of application of various nutrients.
- A variety of factors such as weather and crop type influence the amount of fertilizer used by farmers from year to year. A decrease in usage over time may be due to a reduced reliance on these chemicals or a change in crop rotation, weather, or other factors, and may not be permanent.
- These data do not necessarily reflect residential fertilizer use.

Data Source

The data source for this indicator is the *Agricultural Resources and Environmental Indicators Report,* U.S. Department of Agriculture, Economic Research Service, 2000. (See Appendix B, page B-21, for more information.)

3.2.4 What is the potential disposition of chemicals from land?

Indicators

Pesticide residues in food
Potential pesticide runoff from farm fields
Risk of nitrogen export
Risk of phosphorus export

Disposition describes the potential for chemicals and nutrients to move from their location of use or origin to a place in the environment where humans and other organisms can be exposed to them. People can be affected by these chemicals and nutrients when exposed to them through foods, drinking water supplies, or in the air they breathe. The environment can be affected when these chemicals accumulate on land or enter the water. A significant challenge lies in tracking the movement of pesticides and fertilizers in the environment and then correlating their existence in water or air to health or environmental effects. These chemicals often move through the environment and react in ways that are difficult to track and understand.

Pesticide contamination of ground water is a potential problem when leachable pesticides are applied to soils. Soil leaching potential can be determined by assigning rankings to organic matter, clay content, and acidity, which are the three main factors controlling pesticide leaching through soils (Hellkamp, et al., 1998). Pesticide-leaching potential is a measure of how tightly and quickly a pesticide binds to organic particles and is determined by the leaching potential of the pesticide itself, the pesticide's persistence, and the rate and method of application. Some analysis of the pesticide leaching risk based on these variables has been conducted in the mid-Atlantic region, showing that relatively little acreage has a high potential for leaching. Other variables should also be considered in assessing the risk of pesticide leaching including precipitation, antecedent soil moisture conditions, soil hydraulic conductivities and permeability, and water table depths.

Under ideal circumstances, crops would take up the vast majority of nutrients that are applied as fertilizers to soil, but many factors, including weather, overall plant health, and pests, affect the uptake ability of crops. When crops do not use all applied nutrients, residual concentrations of nutrients and other components of chemical fertilizers remain in the soil and can become concentrated in ground water and surface water. The USGS National Water Quality Assessment provides one measure of these chemical concentrations in waterbodies based on samples from 36 major river basins and aquifers (see Chapter 2, Purer Water). Calculating residual concentrations (known as the "residual balance") for agricultural areas provides an understanding of the potential risks fertilizer use poses to local environmental conditions. If the residual balance is positive, then excessive nutrients may exist and present an ecological risk. If it is negative, then plants are taking up not only the amount of nutrient added by the fertilizer but others already present in the soil and atmosphere. In this case, the soil might be depleted over time (Vesterby, 2003).

Four indicators are considered on the following pages, one that measures the actual presence of chemicals in food, and three that assess the potential for pesticides and nutrients to runoff the land.

Indicator Pesticide residues in food - Category 1

An indication of the amount of pesticides that are detectable in the U.S. food supply provides information about the disposition of some chemicals. Food is one of the pathways through which people can be exposed to the effects of pesticides. USDA has maintained a Pesticide Data Program (PDP) since 1992 that collects data on pesticide residues on fruits, vegetables, grains, and in dairy products at terminal markets and warehouses. Thousands of samples have been analyzed for more than 100 pesticides and their metabolites on dozens of commodities. Samples are collected by USDA immediately prior to these commodities being shipped to grocery stores and supermarkets. They are then prepared in the laboratory as if for consumption (e.g., washed, peeled, cored, but not cooked) so that samples are more likely to reflect actual exposures. Pesticide residue levels are then measured.

What the Data Show

The Department of Agriculture's Pesticide Data Program (PDP) measures pesticide residue levels in fruits, vegetables, grains, and dairy products from across the country, sampling different commodities each year. In 2000, PDP collected and analyzed a total of 10,907 samples: 8,912 fruits and vegetables, 178 rice, 716 peanut butter, and 1,101 poultry tissue samples which originated from 38 States and 21 foreign countries. Approximately 80 percent of all samples were domestic, 19 percent were imported, Indicator Pesticide residues in food - Category 1 (continued)

and less than 1 percent were of unknown origin. Overall, approximately 42 percent of all samples contained no detectable residues, 22 percent contained 1 residue, and 35 percent contained more than 1 residue. Detectable residues are not inherently violations of regulatory tolerances. Residues exceeding the pesticide tolerance were detected in 0.2 percent of all composite samples. Residues with no tolerance level were found in 1.2 percent of all samples. These residues were detected at low concentrations and may be due to spray drift, crop rotations, or cross contamination at packing facilities. PDP reports these findings to the Food and Drug Administration.

Indicator Gaps and Limitations

Limitations for this indicator include the following:

- The PDP does not sample all commodities over all years, so some gaps in coverage exist. For example, a specific commodity might be sampled each year for a two or three year period and then not be sampled for two or more years before being re-sampled during a subsequent period. Differences in the percent of detections for any given class of pesticides might not be due to an increase (or decrease) in the predominance of detectable residues, but might simply reflect the changing nature and identity of the commodities selected for inclusion in any given time frame (given that each PDP "market basket" of goods differs to some extent over time).
- The PDP has the ability to detect pesticide residues at concentrations that are orders of magnitude lower than those determined to have human health effects. The simple presence of detectable pesticide residues in foods should not be considered indicative of a potential health concern (USDA, AMS, 2002).

Data Source

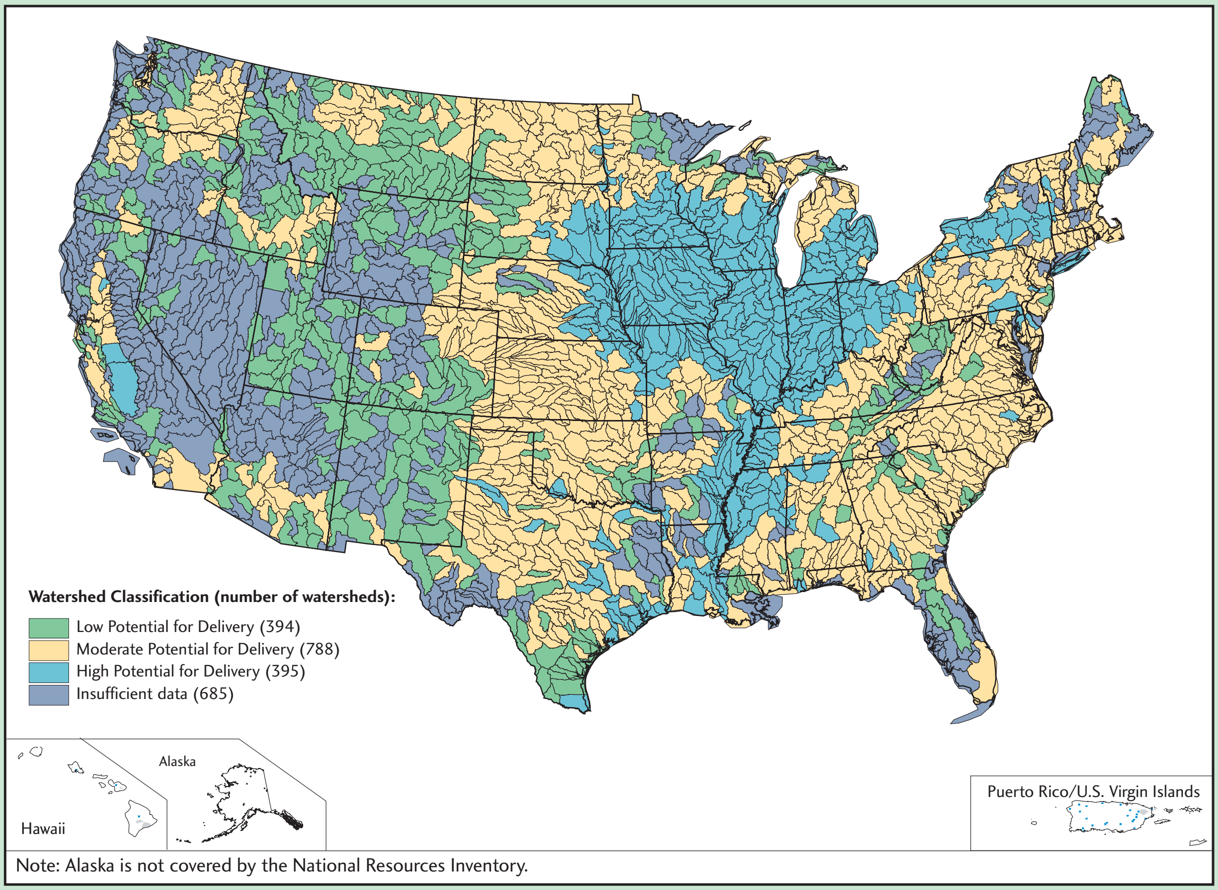
The data source for this indicator is the *Pesticide Data Program: Annual Summary Calendar Year 2000,* U.S. Department of Agriculture, Agricultural Marketing Service. (See Appendix B, page B-21, for more information.)

Indicator Potential pesticide runoff from farm fields - Category 2

This indicator identifies the potential for movement of agricultural pesticides by surface water runoff in watersheds nationwide. The indicator represents potential loss at the edge of a field based on factors that are known to be important determinants of pesticide loss, including: 1) soil characteristics, 2) historical pesticide use, 3) chemical properties of the pesticides used, 4) annual rainfall and its relationship to runoff, and 5) major field crops grown using 1992 as a baseline. Watersheds with high scores (i.e., the "high potential for delivery" class) have a greater risk of pesticide contamination of surface water than do those with low scores (i.e., the "low potential for delivery" class). (See Section 3.1.6 for more on runoff categories.)

Calculations for watershed pesticide runoff potential are based on a National Pesticide Loss Database, that uses the chemical fate and transport model GLEAMS (Groundwater Loading Effects of Agricultural Management). GLEAMS is a model that estimates pesticide leaching and runoff losses using the following as inputs: soil properties, field characteristics (e.g., slope and slope length), management practices, pesticide properties, and climate. GLEAMS estimates were generated for 243 pesticides applied to 120 specific soils; the estimates are for 20 years of daily weather for each of 55 climate stations distributed throughout the U.S. (Knisel, 1993).

Exhibit 3-19: Potential pesticide runoff from farm fields, 1990-1995



Source: USDA, Natural Resources Conservation Service. *National Resources Inventory.* 1992; Gianessi, L.P., and J.E. Anderson. *Pesticide Use in US Crop Production: National Data Report.* February 1995; Goss, Don W. Pesticide Runoff Potential, 1990-1995. August 24, 1999. (September 2002; *http://www.epa.gov/iwi/1999sept/iv12a_usmap.html*).

Indicator Potential pesticide runoff from farm fields - Category 2 (continued)

Chemical use for 13 different crops taken from the National Pesticide Use Database was estimated for 1990-1993 (Gianessi and Anderson, 1995). A total of 145 pesticides were included in the derivation of the pesticide runoff indicator (using the joint set of pesticides from the National Pesticide Use Database and the National Pesticide Loss Database for the 13 crops). Estimates of percent of acres treated and average application rates were imputed to the NRI sample points by crop and state. Each NRI sample point where corn was grown in Iowa, for example, included chemical use for 22 of the pesticides Gianessi and Anderson reported were used on corn in Iowa. The simulation assumed that each pesticide was applied at the average rate for the state. In reality, pesticide use varies widely from field to field. The simulation thus reflects general pesticide use patterns to provide an indication of where the potential for loss from farm fields is the greatest.

The total loss of pesticides from each representative field was estimated by 1) multiplying the estimate of percent loss per acre by the application rate to obtain the mass loss per acre for each pesticide, 2) calculating the number of acres treated for each pesticide by multiplying the estimate of percent acres treated by the number of acres associated with the sample point, 3) multiplying the number of acres treated by the mass loss per acre to obtain the mass loss for the representative field for each pesticide, and 4) summing the mass loss estimates for all the pesticides.

Watershed scores were determined by averaging the scores for the NRI sample points within each watershed. The average watershed score was determined by dividing the aggregate pesticide loss for the watershed by the number of acres of non-federal rural land in the watershed. Dividing by the acres of non-federal rural land provides a watershed level perspective of the significance of pesticide loss.

What the Data Show

Exhibit 3-19 shows the distribution of watersheds and the potential for pesticide runoff nationwide. The highest potential for agricultural pesticide runoff is concentrated in the central U.S., predominately associated with the upper and lower Mississippi River Valley and the Ohio River Valley.

Indicator Gaps and Limitations

The following limitations are associated with this indicator:

- The indicator estimates only the potential for pesticides to run off farm fields. It does not estimate actual pesticide loss. Research has shown that pesticide loss from farmlands can be substantially reduced by management practices that enhance the water-holding capacity and organic content of the soil, reducing water runoff. Where these practices are being used, the potential loss measured by this indicator will be overestimated because the practices are not considered in the analysis.
- The indicator does not include croplands used for growing fruits, nuts, and vegetables. Thus, watersheds with large acreage of these crops will have a greater risk of water quality contamination than shown by this indicator.
- For each field, pesticide usage was assumed as an average for the state, when actual use varies widely.
- This indicator does not address pesticide usage in non-agricultural areas.

Data Sources

The data sources for this indicator are the *Summary Report: 1997 National Resources Inventory (Revised December 2000)*, U.S. Department of Agriculture, Natural Resources Conservation Service, and the National Pesticide Use Database, National Center for Food and Agricultural Policy, 1995. (See Appendix B, page B-21, for more information.)

Indicator Risk of nitrogen export - Category 2

Predictive risk models show higher nutrient concentrations in watersheds dominated by agricultural and urban and suburban land uses. Watersheds with mixed uses tend to have forested lands that reduce concentrations of nutrients. Various field-based studies show a strong relationship between land cover and the amount of nutrients exported from a watershed (e.g., measured in the stream at the watershed outlet) (Beaulac and Reckhow, 1982). Exports are typically measured as mass per unit area per unit time (e.g., lbs/acre/year). Nitrogen exports tend to increase as agriculture and urban and suburban uses replace forest land. Several additional factors affect the actual amount exported, however, such as cropping management practices, the timing of rainfall versus cropping stage, density of impervious surfaces, and soil types.

The risk classes described by this indicator are based solely on proportions of agriculture, forest, and urban and suburban land within a watershed derived from the NLCD. Nutrient export data compiled from watersheds with homogenous land cover were used in a Monte Carlo approach to simulate loads of nitrogen for watersheds with mixed land cover. The model can be used to estimate annual load for any point in the distribution or for risk of exceeding user-defined thresholds. When used to estimate risk, the model conceptually incorporates factors other than land cover as mentioned above.

What the Data Show

Exhibit 3-20 shows the risk of nitrogen export. Risk is expressed as the number of times per 10,000 trials the nitrogen export exceeded a threshold of 6.5 lbs/acre/year. The 6.5 threshold was chosen because it represents the maximum value observed for watersheds that were entirely forest. A risk value of 0.5 indicates a 1 out of 2 chance that a particular watershed would exceed the risk threshold because of its mix of land cover (e.g., forest, agriculture, urban/suburban). The watersheds in Exhibit 3-20 are categorized into five classes based on risk. About 46 percent of the watersheds are in the lowest risk class and 15 percent in the highest. The lowest risk watersheds make up most of the western U.S., northern New England, northern Great Lakes, and southern Appalachians. The highest risk classes are concentrated in the midwestern grain belt. The eastern U.S. shows a mottling of high and low risk classes among adjacent watersheds.

Indicator Gaps and Limitations

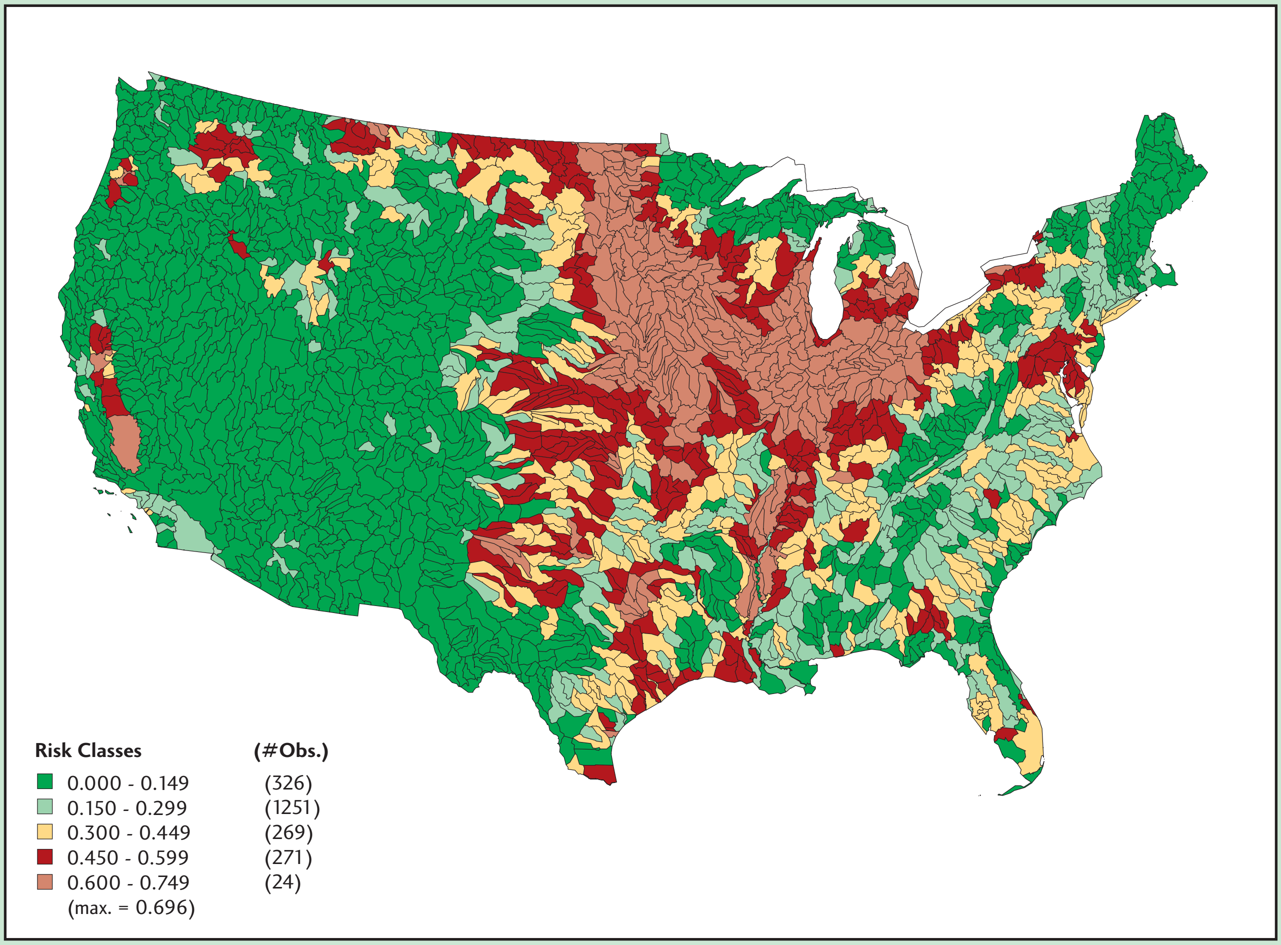
The potential risk of nitrogen runoff calculated from the NLCD data relies on various classifications and models that have inaccuracies that might affect results. To nationally monitor all watershed variables that affect nutrient export is impossible. Therefore, the data for this indicator are based on statistical simulation and the well-documented relationship between land cover and nutrient export to estimate the risk (or likelihood) of export exceeding a certain threshold. The accuracy of the model is affected by the accuracy of the classification of the cover types—forest, agriculture, and urban/suburban—which range from 80 percent to 90 percent in most cases. The accuracy also is affected by lack of model input for other land cover classes that can occur within watersheds, particularly in the western U.S. Model performance has been evaluated in the mid-Atlantic region, and modeled results generally agree with observed values. In the western U.S., shrubland and grassland cover share dominance with forest and agriculture. For national application of the model, shrubland and grassland classes were treated as forest because these land-cover classes, like forest, lack strong anthropogenic inputs of nitrogen. Further research to refine the empirical models for shrubland and grassland cover classes would be useful.

Data Sources

The data source for this indicator is the National Land Cover Data, Multi-Resolution Land Characteristics Consortium, 1992. (See Appendix B, page B-22, for more information.)

Indicator Risk of nitrogen export - Category 2 (continued)

Exhibit 3-20: Estimates of risk of nitrogen export by watershed, 1992



Source: Wickham, J.D. et al., *Land Cover as a Framework for Assessing Risk of Water Pollution.* 2000.

Indicator Risk of phosphorus export - Category 2

Like nitrogen export, the same strong relationship exists between land cover and phosphorus export. Risk is expressed as the number of times out of 10,000 trials that the phosphorus export threshold of 0.74 lbs/acre/year was exceeded. The 0.74 threshold was chosen because it represents the maximum value observed for watersheds that were entirely forest. The model uses an identical approach to that just described in the "risk of nitrogen export" indicator.

What the Data Show

Exhibit 3-21 shows potential for phosphorus export at greater than 0.74 pounds per acre per year. About 74 percent of the watersheds are in the two lowest risk classes. These make up most of the western U.S., as well as the eastern seaboard and the Appalachians. Only 1 percent of the watersheds are in the highest risk classes, and these are scattered throughout the midwestern grain belt, but also in many of the nation's major urban/suburban

Indicator Risk of phosphorus export - Category 2 (continued)

areas. Many major urban/suburban areas exist at the intersection of two watersheds, and the "urban" influence, which would make the phosphorus risk higher, is spread over multiple watersheds. This partially explains why some urban/suburban areas show lower risk than others. Identification of higher phosphorus export risk in urban/suburban areas differs somewhat from the spatial pattern for nitrogen export risk, because the empirical data suggest that urban/suburban areas present higher risk of phosphorus export than nitrogen export.

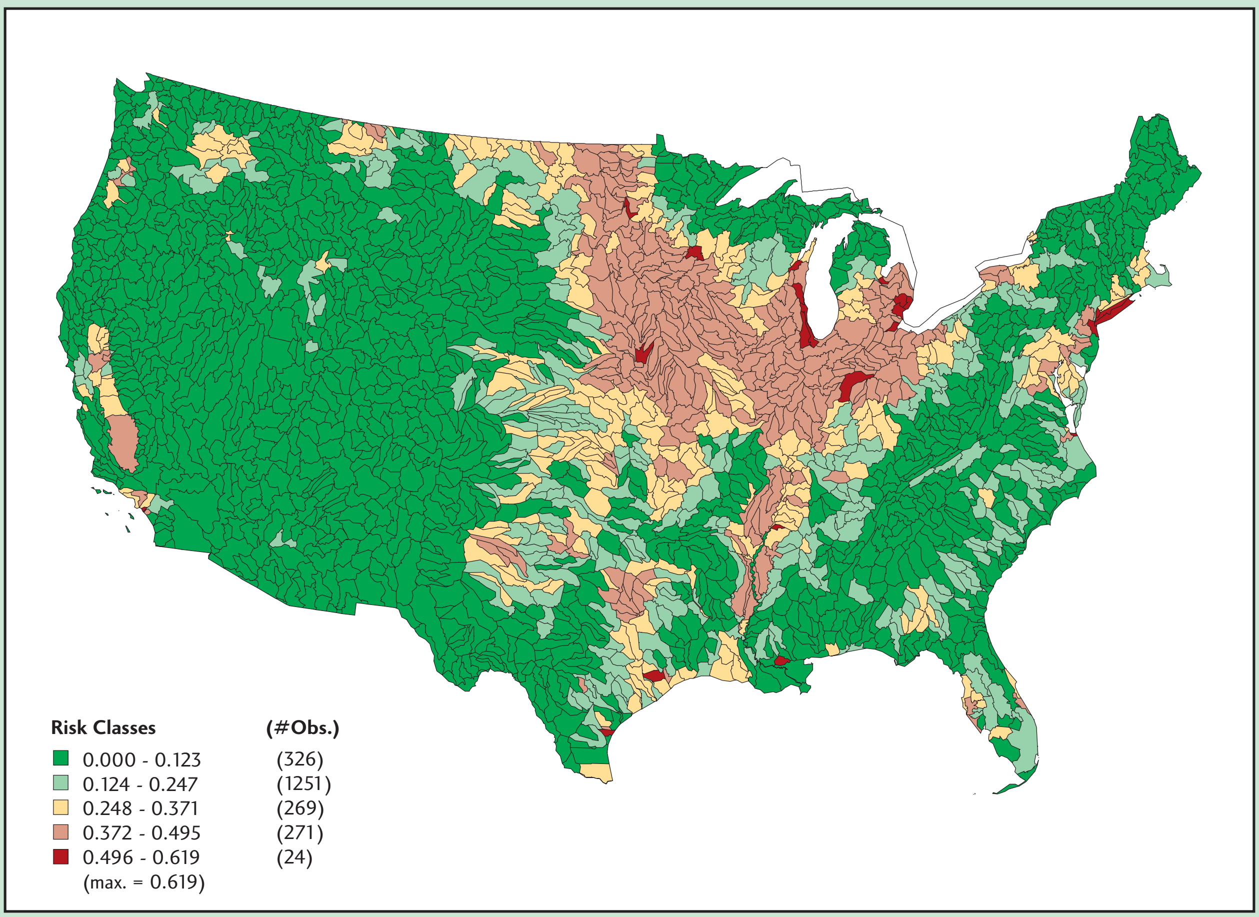
Indicator Gaps and Limitations

The potential risk of phosphorus export is based on the aggregate classes of forest, urban/suburban, and agriculture from the NLCD. Accuracy of these classes ranges from 80 to 90 percent in most cases. Model performance has been evaluated in the mid-Atlantic region, and modeled results generally agree with observed values. In the western U.S., shrubland and grassland cover share dominance with forest and agriculture. For national application of the model, shrubland and grassland classes were treated as forest, because these land-cover classes, like forest, lack strong anthropogenic inputs of phosphorus. Further research to refine the empirical models for shrubland and grassland land-cover classes would be useful.

Data Source

The data source for this indicator is the National Land Cover Data, Multi-Resolution Land Characteristics Consortium, 1992. (See Appendix B, page B-22, for more information.)

Exhibit 3-21: Estimates of risk of phosphorus export by watershed, 1992



Source: Wickham, J.D. et al., *Land Cover as a Framework for Assessing Risk of Water Pollution.* 2000.

3.2.5 What human health effects are associated with pesticides, fertilizers, and toxic substances?

Many pesticides pose some risk to humans and the environment because they are designed to kill or otherwise adversely affect living organisms. The degree to which individuals and populations are exposed to pesticides varies greatly by geographic location and demographics. Children may be more susceptible than adults to the effects of chemicals, including pesticides. Certain populations may be more at risk than others, depending, for example, on sources of drinking water or direct exposure to pesticide application.

Various pesticide surveillance systems exist that collect information on pesticide-related injury and illness, but data are limited. One example, the Toxic Exposure Surveillance System (TESS), contains information from poison control centers around the country that report occurrences of pesticide-related injury and illness.

Other data collected from poison control centers showed that in 2000, more than 100,000 people were sufficiently concerned about exposure to various types of pesticides to call their local Poison Control Center.

The TRI database tracks toxic chemicals because of the risks that these chemicals pose to human health and ecological condition. Studies have made accurate associations between isolated chemicals and their specific health effects. For example, the pesticide atrazine has been shown to have developmental and reproductive effects in animals and fish, depending on the level of exposure (EPA, OPP, 2002). PBT chemicals such as mercury and lead can cause acute or chronic health problems, even when people are exposed to small quantities of the chemicals (See box "Persistant Bioaccumulative Toxic Chemicals") (EPA, October 1999). Though these single chemical assessments are useful, a greater challenge lies in correlating the existence of chemicals that interact in the environment to the health effects observed in a given population.

Fertilizers are often applied in greater quantities than crops can absorb and end up in surface or ground water. Although fertilizers may not be inherently harmful, they can be linked to human health problems when excess nutrients cause algal blooms and eutrophication in waterbodies. Drinking ground water contaminated with runoff from some fertilizers can have severe or even fatal health effects, especially in infants and children (e.g., blue baby syndrome) (Amdur, et al, 1996).

Another emerging issue is the use of recycled industrial waste in fertilizer. Depending on the material and how it is processed, the presence of heavy metals such as lead or cadmium in fertilizers produced with recycled waste can introduce contaminants to the soil and increase the health risks associated with fertilizer use. Many states have begun to test and require labeling for fertilizers containing metals and hazardous waste.

No specific indicators have been identified at this time. There is additional discussion of human health effects of chemical use in Chapter 4, Human Health.

Persistent Bioaccumulative Toxic Chemicals

Human exposure to PBT chemicals increases over time because these chemicals persist and bioaccumulate in the environment. Therefore, even small quantities of these chemicals are of concern. In 1999, EPA lowered the TRI reporting threshold for 13 chemicals called persistent bioaccumulative toxic chemicals (PBTs), including dioxins, mercury, lead, and polychlorinated biphenyls (PCBs). Of the total 38 billion pounds of managed toxic chemicals in 2000, PBTs comprised approximately 72 million pounds. Of the total 7.10 billion pounds of toxic chemicals released to the environment, PBTs accounted for 12.1 million (less than 1 percent). The specific types of PBTs that comprised the 12.1 million pounds were polycyclic aromatic compounds (45 percent), mercury and mercury compounds (36 percent), PCBs (12 percent), pesticides (0.7 percent), and other PBTs (7 percent)(EPA, OEI, 2002).

3.2.6 What ecological effects are associated with pesticides, fertilizers, and toxic substances?

Nitrogen runoff from farmlands and animal feeding operations can contribute to eutrophication of downstream waterbodies and sometimes impair the use of water for drinking water purposes. Nutrient enrichment (nitrogen and phosphorus) is one of the leading causes of water quality impairment in the nation's rivers, lakes, and estuaries. EPA reported to Congress in 1996 that 40 percent of rivers in the U.S. were impaired due to nutrient enrichment; 51 percent of the surveyed lakes and 57 percent of the surveyed estuaries were similarly adversely affected (EPA, OW, December 1997). Nutrients have also been implicated in identification of the large hypoxic zone in the Gulf of Mexico, hypoxia observed in several East Coast states, and harmful algal bloom-induced fish kills and human health problems in the coastal waters of several East Coast and Gulf states .

Just as the sources of nitrogen in watersheds vary, so do the effects of exported nitrogen. While high levels of nitrogen might not affect the watersheds from which the nutrient is exported, exports can influence the condition of coastal estuaries and lakes. The effects vary with such factors as water-column mixing, sunlight, temperature, and the availability of other nutrients.

No specific indicators have been identified at this time. Effects of chemical use on ecological condition are discussed more extensively in Chapter 2, Purer Water; and Chapter 5, Ecological Condition.

3.3 Waste and Contaminated Lands

Waste and contaminated lands are discussed in this section. Waste is broadly defined as unwanted materials left over from manufacturing processes or refuse from places of human or animal habitation. Several waste categories and types are included within this broad definition. In general, waste can be categorized as either hazardous or non-hazardous. Hazardous wastes are the by-products of society that can pose substantial or potential hazards to human health or the environment when improperly managed. These wastes may appear on special EPA lists and they possess at least one of the four following characteristics: ignitability, corrosivity, reactivity, or toxicity. Hazardous waste includes specific types of waste, such as toxic waste and radioactive waste. All other waste is considered to be non-hazardous (EPA, OEI, May 2002).

Several specific kinds of waste consist of mixed hazardous and non-hazardous content. For instance, municipal solid waste (e.g., garbage) is largely non-hazardous but does typically contain some household hazardous waste items such as solvents or batteries. Other materials and waste types that can have mixed hazardous/non-hazardous content include animal waste, by-products of oil and gas production, materials from leaking underground storage tanks, and waste from coal combustion.

Contaminated lands are lands that have been contaminated with hazardous materials and require remediation. Contaminated lands are not the same as lands used for waste management. In many instances, lands used for waste management are not contaminated. Similarly, often no waste is present on contaminated lands. Contaminated lands can pose a direct risk if they expose people, animals, or plants to harmful materials or cause the contamination of air, soil, sediment, surface water, or ground water.

Despite numerous waste-related data collection efforts at the state and national levels, nationally consistent and comprehensive data on the status, pressures, and effects of waste and contaminated lands are limited. Various parties are responsible for tracking types and amounts of waste and contaminated sites. National-level data on waste and contaminated land tend to be collected to satisfy the requirements of specific federal regulations. For example, EPA's Resource Conservation and Recovery Act Information System (RCRAInfo) contains data on RCRA hazardous waste and EPA's Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) contains some data on contaminated sites, including Superfund sites.

Few national data sets exist for the waste types that are not federally regulated, such as non-hazardous industrial waste. Although a significant amount of waste information and some site contamination information is collected and tracked at the local or state government levels, these data are seldom aggregated nationally. Also, most of the available data describe waste in terms of weight, rather than volume. The weight data alone do not address the extent of the waste situation in the U.S. Similarly, national information about contaminated lands tends to focus on number of sites and types of contamination, rather than the extent of land contaminated. Finally, there is a lack of national data that track the effects of waste and contaminated land on human health and ecological condition.

While major improvements have been made in managing the nation's waste and cleaning up contaminated sites, more work remains. National, state, tribal, and local waste programs and policies aim to prevent pollution by reducing the generation of wastes at their source and by emphasizing prevention over management and disposal. Preventing pollution before it is generated and poses harm is often less costly than cleanup and remediation. Source reduction and recycling programs often can increase resource and energy efficiencies, reduce pressures on the environment, and extend the life span of disposal facilities.

The following questions and discussion of indicators provide an overview of what is known about waste generation and management and about contaminated lands in the U.S. Trends and conditions on a national basis are described to the extent that data are available. The five questions considered in this section are:

- How much and what types of waste are generated and managed?
- What is the extent of land used for waste management?
- What is the extent of contaminated land?
- What human health effects are associated with waste management and contaminated lands?
- What ecological effects are associated with waste management and contaminated lands?

EPA is the primary source of data for this section, providing municipal solid waste data on generation, management, recovery, and disposal; data on RCRA hazardous waste and corrective action sites from the RCRAInfo database; and data on the number and location of contaminated sites that are on the Superfund National Priorities List (NPL) from CERCLIS. The U.S. Department of Energy's (DOE) Central Internet Database provides information on the types and quantities of radioactive waste generated and in storage.

3.3.1 How much and what types of waste are generated and managed?

Indicators

Quantity of municipal solid waste (MSW) generated and managed
Quantity of RCRA hazardous waste generated and managed
Quantity of radioactive waste generated and in inventory

There are numerous types of waste, but only three types are tracked with any consistency on a national basis. The three that are described as indicators on the following pages include municipal solid waste (MSW), hazardous waste (as defined by RCRA), and radioactive waste. The other types of waste range from materials generated during mining and agricultural activities to wastes from manufacturing and construction. Current national data are not available on these other types of waste. Exhibit 3-22 summarizes the types of waste.

Exhibit 3-22: Types of Waste

Type	Description
Municipal Solid Waste (Indicator)	Municipal solid waste (MSW) is the waste discarded by households, hotels/motels, and commercial, institutional, and industrial sources. MSW typically consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. It does not include wastewater. In 2000, 232 million tons of MSW were generated. (EPA, OSWER, June 2002)
RCRA Hazardous Waste (Indicator)	The term "RCRA hazardous waste" applies to certain types of hazardous wastes that appear on EPA's regulatory listing (RCRA) or that exhibit the specific characteristics of ignitability, corrosiveness, reactivity, or toxicity. More than 40 million tons of RCRA hazardous waste were generated in 1999. (EPA, OSWER, June 2001)
Radioactive Waste (Indicator)	Radioactive waste is the garbage, refuse, sludge, and other discarded material, including solid, liquid, semi-solid, or contained gaseous material that must be managed for its radioactive content (DOE Order 435.1 Issued July 1999). The technical names for the types of waste that are considered "radioactive waste" for this report are high-level waste, spent nuclear fuel, transuranic waste, low-level waste, mixed low-level waste, and contaminated media. Data on the amounts of these waste types are provided in the radioactive waste discussion. (See Appendix D for definitions of these terms).
Extraction Wastes	Extraction activities such as mining and mineral processing are large contributors to the total amount of waste generated and land contaminated in the U.S. EPA estimates that 5 billion tons of mining wastes were generated in 1988 (EPA, OSWER, October 1988).
Industrial Non-Hazardous Waste	Industrial non-hazardous waste is process waste associated with electric power generation and manufacturing of materials such as pulp and paper, iron and steel, glass, and concrete. This waste usually is not classified as either municipal solid waste or RCRA hazardous waste by federal or state laws. State, tribal, and some local governments have regulatory programs to manage industrial waste. EPA estimated that 7.6 billion tons of industrial non-hazardous wastes were generated in 1988. (EPA, OSWER, October 1988)
Household Hazardous Waste	Most household products that contain corrosive, toxic, ignitable, or reactive ingredients are considered household hazardous waste. Examples include most paints, stains, varnishes, solvents, and household pesticides. Special disposal of these materials is necessary to protect human health and the environment, but some amount of this type of waste is improperly disposed of by pouring the waste down the drain, on the ground, in storm sewers, or by discarding the waste with other household waste as part of municipal solid waste. EPA estimates that Americans generate 1.6 million tons of household hazardous waste per year, with the average home accumulating up to 100 pounds annually. (EPA, OSWER, October 2002)
Agricultural Waste	Agricultural solid waste is waste generated by rearing animals and producing and harvesting crops or trees. Animal waste, a large component of agricultural waste, includes waste from livestock, dairy, milk, and other animal-related agricultural and farming practices. Some of this waste is generated at sites called Confined Animal Feeding Operations (CAFOs). The waste associated with CAFOs results from congregating animals, feed, manure, dead animals, and production operations on a small land area. Animal waste and wastewater can enter water bodies from spills or breaks of waste storage structures (due to accidents or excessive rain) and non-agricultural application of manure to crop land (EPA, OW, November 2001; EPA, OW, June 2002). National estimates are not available.
Construction and Demolition Debris	Construction and demolition debris is waste generated during construction, renovation, and demolition projects. This type of waste generally consists of materials such as wood, concrete, steel, brick, and gypsum. (The MSW data in this report do not include construction and demolition debris, even though sometimes construction and demolition debris are considered MSW.) National estimates are not available.
Medical Waste	Medical waste is any solid waste generated during the diagnosis, treatment, or immunization of human beings or animals, in research, production, or testing. National estimates are not available.
Oil and Gas Waste	Oil and gas production wastes are the drilling fluids, produced waters, and other wastes associated with the exploration, development, and production of crude oil or natural gas that are conditionally exempted from regulation as hazardous wastes. National estimates are not available.
Sludge	Sludge is the solid, semisolid, or liquid waste generated from municipal, commercial, or industrial wastewater. National estimates are not available.

Indicator Quantity of municipal solid waste (MSW) generated and managed - Category 2

As noted in Exhibit 3-22, municipal solid waste (MSW) is the waste discarded by households and by commercial, institutional, and industrial operations. This type of waste is familiar to most Americans because they are specifically responsible for its generation. MSW typically consists of everyday items such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. It does not include wastewater.

What the Data Show

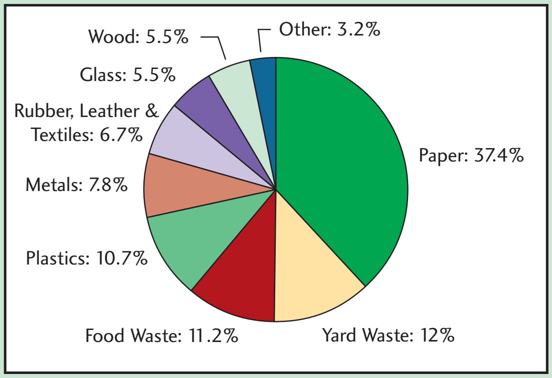
In 2000, Americans generated 232 million tons of MSW (Exhibit 3-23). This total amount, which does not take into account MSW that was ultimately recycled or composted, equated to approximately 4.5 pounds of waste per person per day. Paper and paperboard products accounted for the largest component of MSW generated (37 percent), and yard trimmings constituted the second-largest material component (12 percent). Glass, metals, plastics, wood, and food scraps each constituted 5 to 11 percent of the total. Rubber, leather, and textiles combined made up about seven percent of MSW, while other miscellaneous wastes made up approximately 3 percent (EPA, OSWER, June 2002).

The total amount of MSW generated increased nearly 160 percent between 1960 and 2000 (Exhibit 3-24). For comparison purposes, during that same time frame, the U.S. population increased by 56 percent, gross national product increased nearly 300 percent, and per capita generation of waste rose more than 70 percent (DOC, BEA, 2002; EPA, OSWER, June 2002). The amount of MSW generated per capita generally stabilized between 1990 and 2000, increasing less than one percent.

The data on the total amount of MSW generated do not factor in source reduction and waste prevention or materials recovery (recycling and composting), which are also important contributors to the overall municipal waste picture. Source reduction and waste prevention include the design, manufacture, purchase, or reuse of materials to reduce their amount or toxicity or lengthen their life before they enter the MSW system. Between 1992 and 2000, source reduction in the U.S. prevented more than 55 million tons of MSW from entering the waste stream (EPA, OSWER, June 2002) (Exhibit 3-25).

Exhibit 3-23: Total municipal solid waste generated, 2000

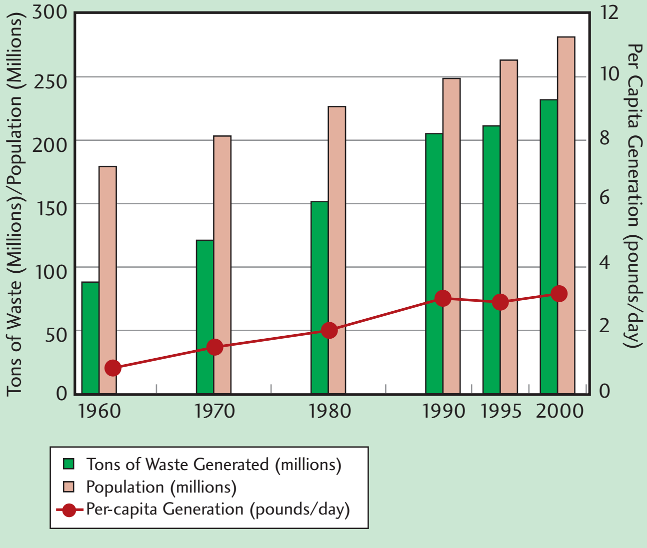
Total (before recycling and composting) = 232 million tons



Source: EPA, Office of Solid Waste and Emergency Response. *Municipal Solid Waste in the United States: 2000 Facts and Figures.* June 2002.

Exhibit 3-24: Municipal solid waste generation rates, 1960-2000

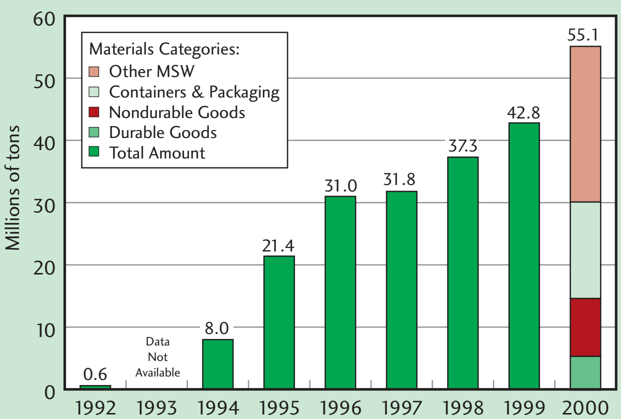
(before recycling and composting)



Source: EPA, Office of Solid Waste and Emergency Response. *Municipal Solid Waste in the United States: 2000 Facts and Figures.* June 2002.

Indicator | Quantity of municipal solid waste (MSW) generated and managed - Category 2 (continued)

Exhibit 3-25: Source reduction of municipal solid waste, 1992-2000

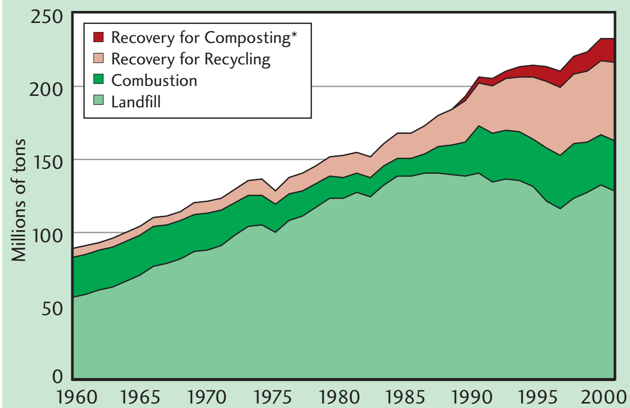


Source: EPA. Office of Solid Waste and Emergency Response. *Municipal Solid Waste in the United States: 2000 Facts and Figures*. June 2002.

Materials recovery (recycling and composting) has also reduced the total amount of MSW being discarded. In 2000, approximately 30 percent (70 million tons) of the MSW generated was recovered and thereby diverted from landfills and incinerators. Between 1960 and 2000, the total amount of MSW recovered has significantly increased from 5.6 million tons to 69.9 million tons, more than a 1,100 percent increase. During this time period, the amount recovered on a per capita basis increased from 0.17 pounds per person per day to 1.35 pounds per person per day—an 8-fold increase (EPA, OSWER, June 2002). The percentage of MSW disposed of in landfills has dropped from 83.2 percent of the amount generated in 1986 to 55.3 percent of the amount generated in 2000 (Exhibit 3-26). Combustion (incineration) is also used to reduce waste volume prior to disposal in a land-based waste management facility. Approximately 33.7 million tons (14.5 percent) of MSW were combusted in 2000. Of this amount, approximately 2.3 million tons were combusted with energy recovery—also known as waste-to-energy combustion (EPA, OSWER, June 2002).

Exhibit 3-26: Municipal solid waste management, 1960-2000

(2000 total = 232 million tons)



* Composting of yard trimmings and food wastes. Does not include mixed MSW composting or backyard composting.

Source: EPA, Office of Solid Waste and Emergency Response. *Municipal Solid Waste in the United States: 2000 Facts and Figures*. June 2002.

Indicator Gaps and Limitations

Limitations for this indicator include the following:

- The MSW data do not include construction and demolition debris, municipal waste water treatment sludge, automobile bodies, combustion ash, and non-hazardous industrial wastes that may go to a municipal waste landfill. The data (including the generation, recycling, and recovery data) are generated using the materials flow method, which does not include these materials, even though some of these materials (namely construction and demolition debris) are typically counted as MSW.
- Residues associated with other items in MSW (usually containers) are not accounted for in the data.
- The percentage of total waste that MSW represents is unknown.
- The indicator does not necessarily measure the effects of changes in consumer or disposal trends.

Data Source

The data source for this indicator is Municipal Solid Waste Data, EPA, Office of Solid Waste and Emergency Response, 1990-2000. (See Appendix B, page B-22, for more information.)

Indicator Quantity of RCRA hazardous waste generated and managed - Category 2

Businesses that generate a substantial amount of RCRA hazardous waste as part of their regular activities are called "large quantity generators" or LQGs. ("Substantial" is defined as more than 2,200 pounds per month.) National data on "small quantity generators" (SQGs) and "conditionally-exempt small quantity generators" (CESQGs) are not available. Estimates indicate, however, that the amount of RCRA hazardous waste that SQGs and CESQGs generate is relatively small (EPA, OSWER, June 2000).

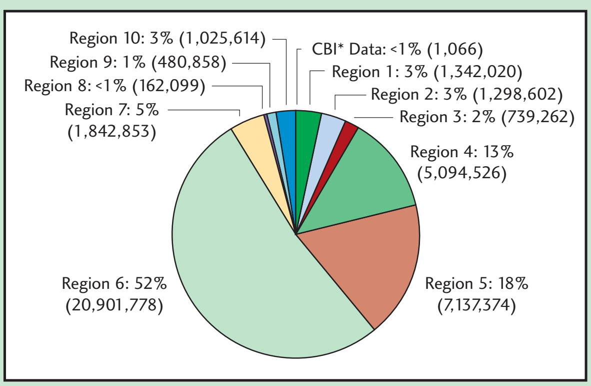
What the Data Show

In 1999, EPA estimated that more than 20,000 LQGs collectively generated 40 million tons of RCRA hazardous waste (EPA, OSWER, June 2001). The number reflects between 95 and 99 percent of the total amount of RCRA hazardous waste generated. The exact total amount of RCRA hazardous waste generated by LQGs, SQGs, and CESQGs combined is not known, but the contributions of SQGs and CESQGs are estimated to be between 0.4 million tons and 2.1 million tons (or 1 to 5 percent) of the total amount of RCRA hazardous waste (EPA, OSWER, June 2000).

LQGs within EPA Region 6 (see Exhibit 1-12 for Regional delineation) generated more than half of all RCRA hazardous waste in 1999 (Exhibit 3-27). Less than 9 percent of the LQGs nationwide are located in Region 6, but 15 of the 22 largest national generators (by quantity generated) are there. Of the large Region 6 generators, 13 manufacture chemicals, petrochemicals, minerals, and metal; and two manage chemical wastes. Generation in Regions 4 and 5 accounted for 18 percent and 13 percent of the national total, respectively, and all other Regions combined accounted for the remaining 17 percent (EPA, OSWER, June 2001).

Exhibit 3-27: Amount of Resource Conservation and Recovery Act (RCRA) hazardous waste generated in EPA regions, 1999

(Tons)



* Confidential Business Information not shown in pie chart

Source: EPA, Office of Solid Waste and Emergency Response. *The National Biennial RCRA Hazardous Waste Report. June* 2001.

Assessing trends in hazardous waste is difficult because the data collected over the last several years have changed. For example, the exclusion of wastewater from the 1999 totals makes a comparison of the 1999 data with previous data (which included wastewater) misleading. What is known, however, is that the amount of a specific set of toxic chemicals (Waste Minimization Priority Chemicals, or WMPC) found in hazardous waste is declining. (See the discussion of WMPC in the "Chemicals in the Landscape" section of this chapter.)

RCRA hazardous waste management is conducted at RCRA treatment, storage, and disposal facilities (TSDs) (see indicator in the following pages on Land Used for Waste Management). In 1999, TSDs managed 26.3 million tons of hazardous waste through treatment, storage, or disposal.

The (non-wastewater) management methods used in 1999 were as follows:

- Land disposal (69 percent): Includes deepwell/underground injection (16.0 million tons), landfill (1.4 million tons), surface impoundment (0.7 million tons), and land treatment/application/farming (30 thousand tons). Prior to land disposal, hazardous waste is treated to reduce toxicity and to prevent exposure of people and the environment to harmful constituents.
- Thermal treatment (11 percent): Includes energy recovery (1.5 million tons) and incineration (1.5 million tons).
- Recovery operations (10 percent): Includes fuel blending (1.1 million tons), metals recovery for reuse (0.72 million tons), solvents recovery (368 thousand tons), and other recovery (152 thousand tons).
- Other (11 percent): Includes other disposal (1.4 million tons), stabilization (1.3 million tons), sludge treatment (48 thousand tons) (EPA, OSWER, June 2001).

Indicator Quantity of RCRA hazardous waste generated and managed - Category 2 (continued)

Indicator Gaps and Limitations

While RCRAInfo is a reliable source of data about much of the hazardous waste generated throughout the U.S., it does not provide information about all hazardous waste generated nationally. RCRAInfo includes data on amounts and types of hazardous waste generated nationally by large quantity generators only. Data about amounts and types of hazardous waste generated by RCRA SQGs and CESQGs are not collected. Similarly, data on waste that does not fit the RCRA definition of "hazardous" are not available. Some states regulate and collect data on wastes they designate as "hazardous" that are not tracked by EPA, but these data are not aggregated nationally.

Data Source

The data source for this indicator is 1999 RCRAInfo data, from EPA, Office of Solid Waste and Emergency Response. (See Appendix B, page B-22, for more information.)

Indicator Quantity of radioactive waste generated and in inventory - Category 2

The manufacture and production of nuclear materials and weapons requires activities that can generate large amounts of radioactive waste. Over the past few decades, the production of nuclear weapons has largely been suspended. The largest quantities of radioactive waste generated today (when measured by volume) result from the cleanup of contaminated sites.

What the Data Show

A significant amount of the radioactive waste in existence today will remain radioactive for many years—in some cases thousands of years. When measured by volume, the radioactive waste that is still being generated reflects only a small percentage (<10 percent) of the total amount of waste that is either in storage (inventory) or disposed of already. When measured by radioactivity, the amount of radioactive waste in inventory far exceeds the radioactivity of newly-generated radioactive waste (U.S. DOE, April 2001). Exhibit 3-28 provides summary data on the total amount of radioactive waste generated and in inventory (storage) at the end of fiscal year (FY) 2000.

Over time, the amount of radioactive waste generated has fluctuated primarily due to the progress of site cleanup operations. Trend data on generation rates over the past several years are not available. According to the DOE, however, the amount of waste generated between late 1997 and late 2000 remained fairly constant, while the amount in inventory increased in proportion to the amount generated (DOE, 2002). Although some radioactive waste is still being disposed of (e.g., small amounts of transuranic waste are being disposed of at the Waste Isolation Pilot Plant in New Mexico), most of the highly radioactive waste types remain in storage until they can be placed in safe long-term disposal facilities.

The amount of radioactive waste being generated and stored is expected to drop over the next few decades as cleanup operations are completed and waste currently in storage is disposed of. Depending on the radioactive decay rate, the disposed-of waste will remain radioactive for time periods ranging from days to thousands of years.

Indicator Gaps and Limitations

The radioactive waste data in this report do not account for all radioactive materials in the U.S. The term "radioactive waste" applies to any garbage, refuse, sludge, and other discarded material that must be managed for its radioactive content (DOE Order 435.1, issued July 1999). Other radioactive materials are used for defense, energy production, and other purposes, but these materials are not considered "waste." Further, DOE is not responsible for some additional radioactive waste (quantity unknown). Data on these wastes are not included in this report.

Data Source

The data source for this indicator is radioactive waste data, from U.S. Department of Energy's Central Internet Database, 2000. (See Appendix B, page B-23, for more information.)

Indicator | Quantity of radioactive waste generated and in inventory - Category 2 (continued)

Exhibit 3-28: Total amount of radioactive waste* generated in fiscal year 2000 as reported by Department of Energy

Waste Type	Generated	Inventory (Storage)	Units
Vitrified High-Level Waste	n/a	1,201	Canisters
High-Level Waste	14,166	353,501	Volume (cubic meters)
Low-Level Waste	38,911	101,256	
Mixed Low-Level Waste	10,834	44,588	
Ex-Situ Contaminated Media	559,249	63,570	
Transuranic Waste	1,621	111,226	
Spent Nuclear Fuel	0.85	2,467	Mass (metric tons of heavy metal)

Source: U.S. Department of Energy, Office of Environmental Management, Central Internet Database. 2002. (January 2003; *http://cid.em.doe.gov*).

* For the purposes of this report, all of the materials in this table are considered radioactive waste.

3.3.2 What is the extent of land used for waste management?

Indicators

Number and location of municipal solid waste (MSW) landfills

Number and location of RCRA hazardous waste management facilities

Most types of waste are disposed of in land-based waste management units such as MSW landfills and surface impoundments. Prior to the 1970s, waste disposed of on the land was typically dumped in open pits, and waste was seldom treated to reduce its toxicity prior to disposal (EPA, OSWER, June 2002). Early land disposal units that still pose threats to human health and the environment are considered to be contaminated lands subject to federal or state cleanup efforts and are discussed in the next section. Today, most of the hazardous and MSW land disposal units are subject to federal or state requirements for landfill, surface impoundment, or pile design and management. National data for these disposal units is described in the indicators following.

Many other sites are used for waste management in addition to the MSW landfills and RCRA hazardous waste facilities just mentioned. Although comprehensive data sets are not available to assess the number of additional sites used for waste management, various EPA estimates show that there were approximately 18,000 non-hazardous industrial waste surface impoundments in 2000, more than 2,700 non-hazardous industrial waste landfills in 1985, and more than 5,300 non-hazardous industrial waste piles in 1985 (EPA, OSWER, March 2001). These numbers do not include other waste management sites, such as those used to collect and manage (but not dispose of) waste (e.g., recycling centers, household hazardous waste collection centers), waste transfer stations, sites that store discarded automobile and industrial equipment, and non-regulated landfills.

The two indicators identified for this question address the number and location of MSW landfills and RCRA facilities.

Indicator: Number and location of municipal solid waste (MSW) landfills - Category 2

Municipal solid waste landfills are the most commonly known places of waste disposal. Yet this does not mean that there are good data to track them. The data presented in support of this indicator are estimates compiled by a national journal. No federal agency specifically compiles information nationally on these landfills.

What the Data Show

In 2000, approximately 128 million tons (55 percent) of the nation's 232 million tons of MSW were disposed of in the nation's 2,216 municipal waste landfills (EPA, OSWER, June 2002). Between 1989 and 2000, the number of municipal landfills in the U.S. decreased substantially (down from 8,000). Over the same period, the capacity of all landfills remained fairly constant because newer landfills typically have larger capacities. In 2000, these landfills were geographically distributed as follows: 154 (8 percent) in the Northeast, 699 (35 percent) in the Southeast, 459 (23 percent) in the Midwest, and 655 (33 percent) in the West (Goldstein, 2000).

Indicator Gaps and Limitations

MSW data are voluntarily submitted to BioCycle Journal and are not reviewed for quality or consistency. The data exclude landfills in Alaska and Hawaii and do not indicate the capacity or volume of landfills, or in general, a means to estimate extent of lands used for MSW management. For example, the fact that there are fewer landfills does not mean that less land is used for managing wastes because newer landfills are typically larger than their predecessors. The information is also limited by the fact that other lands are also used for waste management, such as for recycling facilities and waste transfer stations, but are not included in the indicator data. The data also do not reflect upon the status or effectiveness of landfill management or the extent to which contamination of nearby lands does or does not occur.

Data Source

The data source for this indicator is *BioCycle Journal* municipal landfill data 1990-2000. (See Appendix B, page B-23, for more information.)

Indicator: Number and location of RCRA hazardous waste management facilities - Category 2

The RCRA Treatment, Storage, and Disposal (TSD) facilities used to manage the more than 26 million tons of annually generated hazardous waste are tracked closely by EPA. The data, however, are tracked and reported in terms of number of facilities and volumes of waste managed, not the acres of land used for management.

What the Data Show

Nearly 70 percent of the RCRA hazardous waste (not including wastewater) generated in 1999 was disposed of at one of the nation's 1,575 RCRA TSDs. Of the 1,575 facilities, 1,049 were storage-only facilities. The remaining facilities perform one or more of the following management methods, which include recovery operations (the percentages reflect the percentage of total facilities that conduct each management method): metals recovery (16.8 percent), solvents recovery (21.1 percent), other recovery (8.8 percent), incineration (28.4 percent), energy recovery (18.9 percent), fuel blending (19.8 percent), sludge treatment (3.0 percent), stabilization (16.0 percent), land treatment/application/farming (1.3 percent), landfill (11.4 percent), surface impoundment (0.4 percent), deepwell/underground injection (8.8 percent), or other disposal methods (7.4 percent).

TSD facilities in five states accounted for approximately 65 percent of the national management total. From another perspective, over 80 percent of the TSD facilities are located in EPA Regions 4 (19.6 percent), Region 5 (16.9 percent), and Region 6 (43.7 percent) (EPA, OSWER, June 2001).

Indicator Gaps and Limitations

Some hazardous waste management information that is collected by states is not included in the provided totals because it is not compiled nationally. Further, data on actual extent of land used for waste management are not collected, reported, or aggregated. Basic data on the number of sites or facilities used for waste management do not answer the extent question.

Data Source

The data source for this indicator is 1999 RCRAInfo data from EPA Office of Solid Waste and Emergency Response. (See Appendix B, page B-23, for more information.)

3.3.3 What is the extent of contaminated lands?

Indicators

Number and location of superfund national priorities list (NPL) sites
Number and location of RCRA corrective action sites

Contaminated lands range from sites where underground storage tanks have failed to areas where accidental spills have occurred to legacy sites where poor site management resulted in the contamination of soil, sediment, and ground water. Sites are still being discovered and national data do not currently exist to describe the full extent of contaminated lands. Additionally, sites are continually being cleaned up by a variety of programs, although these sites are not always immediately removed from the tracking lists maintained by the cleanup programs (e.g., Superfund NPL).

Two indicators are described. One addresses Superfund (NPL) sites and the other RCRA Corrective Action sites. They represent the limited data available for a national view of contaminated lands. Both indicators are based on data collected to track cleanup efforts and list numbers of sites, but neither specifically delineate the extent or total area of land contamination. Besides these two indicators that track specific programs, there are several other types of contaminated lands for which national data are limited or are not available. In some cases, states collect and maintain accurate data inventories, but these state-specific data sets are not compiled nationally. Exhibit 3-29 summarizes the types of lands that are or might be considered contaminated.

Exhibit 3-29: Types of contaminated lands

Type	Description
Superfund National Priorities List Sites (Indicator)	Congress established the Superfund Program in 1980 to clean up abandoned hazardous waste sites throughout the U.S. The most seriously contaminated sites are on the NPL. As of October 2002, there were 1,498 sites on the NPL (EPA, SERP, October 2002).
RCRA Corrective Action Sites (Indicator)	EPA and authorized states have identified 1,714 hazardous waste management facilities that are the most seriously contaminated and may pose significant threats to humans or the environment (EPA, OSWER, October, 2002). Some RCRA Corrective Action sites are also identified by the Superfund Program as NPL sites.
Leaking Underground Storage Tanks	EPA regulates many categories of underground storage tanks (USTs), often containing petroleum or hazardous substances. These exist at many sites, such as gas stations, convenience stores, and bus depots. USTs that have failed due to faulty materials, installation, operating procedures, or maintenance systems are categorized as leaking underground storage tanks (LUSTs). LUSTs can contaminate soil, ground water, and sometimes drinking water. Vapors from UST releases can lead to explosions and other hazardous situations if those vapors migrate to a confined area such as a basement. LUSTs are the most common source of ground water contamination (EPA, OW, 2000), and petroleum is the most common ground water contaminant (EPA, OW, 1996). According to EPA's corrective action reports, in 1996 there were 1,064,478 active tanks located at approximately 400,000 facilities. In 2002, there were 697,966 active tanks (a 34 percent decrease) and 1,525,402 closed tanks (a 42 percent increase). As of the fall of 2002, 427, 307 UST releases (LUSTs) were confirmed. (EPA, OSWER, December 2002).
Accidental Spill Sites	Each year, thousands of oil and chemical spills occur on land and in water. Oil and gas materials that have spilled include drilling fluids, produced waters, and other wastes associated with the exploration, development, and production of crude oil or natural gas. Accurate national spill data are not available.

Exhibit 3-29: Types of contaminated lands (continued)

Type	Description
Land Contaminated with Radioactive and Other Hazardous Materials	Approximately 0.54 million acres of land spanning 129 sites in over 30 states are contaminated with radioactive and other hazardous materials as a result of activities associated with nuclear weapons production and research. Although DOE is the landlord at most of these sites, other parties, including other federal agencies, private parties, and one public university, also have legal responsibilities over these lands (DOE, January 2001).
Brownfields	Brownfields are 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 (Small Business Liability Relief and Brownfields Revitalization Act, 2002). Brownfields are often found in and around economically depressed neighborhoods. As brownfields are cleaned and redeveloped, surrounding communities benefit from a reduction of health and environmental risks, more functional space, and improved economic conditions. A complete inventory of brownfields does not exist. According to the General Accounting Office (1987), there are approximately 450,000 brownfields nationwide (General Accounting Office, 1987). The EPA's national brownfield tracking system includes a large volume of data on brownfields across the nation, but does not track all of them. EPA's Brownfield Assessment Pilot Program includes data collected from over 400 pilot communities (EPA, OSWER, May 2002).
Some Military Bases	Some (exact number or percentage unknown) military bases are contaminated as a result of military activities. A national assessment of land contaminated at military bases has not been conducted; however, under the Base Realignment and Closure (BRAC) laws, closed military bases undergo site investigation processes to determine extent of possible contamination and the need for site cleanup. Currently, 204 military installations that have been closed or realigned are undergoing environmental cleanup. These installations collectively occupy over 400,000 acres, though not all of this land is contaminated. Thirty-six of these installations are on the Superfund NPL list, and, of these, 32 are being cleaned up under the Fast Track program to make them available for other uses as quickly as possible (DOD, 2001).
Poorly Designed or Poorly Managed Waste Management Sites	Prior to the 1970s, untreated waste was typically placed in open pits or directly onto the land. Some of these early waste management sites are still contaminated. In other cases, improper management of facilities (that were typically used for other purposes such as manufacturing) resulted in site contamination. Federal and state cleanup efforts are now addressing those early land disposal units and poorly-managed sites that are still contaminated.
Illegal Dumping Sites	Also known as "open dumping" or "midnight dumping," illegal dumping of such materials as construction waste, abandoned automobiles, appliances, household waste, and medical waste raises concerns for safety, property values, and quality of life. While a majority of illegally dumped waste is not hazardous, some of it is, creating contaminated lands.
Abandoned Mine Lands	Abandoned mine lands are sites that have historically been mined and have not been properly cleaned up. These abandoned or inactive mine sites may include disturbances or features ranging from exploration holes and trenches to full-blown, large-scale mine openings, pits, waste dumps, and processing facilities. The Department of the Interior's (DOI) Bureau of Land Management (BLM) is presently aware of approximately 10,200 abandoned hardrock mines located within the roughly 264 million acres under its jurisdiction. Various government and private organizations have made estimates over the years about the total number of abandoned and inactive mines in the U.S., including estimates for the percent land management agencies, and state and privately-owned lands. Those estimates range from about 80,000 to hundreds of thousands of small to medium-sized sites. The BLM is attempting to identify, prioritize, and take appropriate actions on those historic mine sites that pose safety risks to the public or present serious threats to the environment (DOI, BLM, 2003).

Indicator Number and location of Superfund National Priorities List (NPL) sites - Category 2

Congress established the Superfund Program in 1980 to clean up abandoned hazardous waste sites throughout the U.S. The Superfund Program tracks and investigates thousands of potentially contaminated sites to determine whether they are indeed contaminated and require cleanup. Some sites are not contaminated, whereas others are seriously contaminated and require either extensive, long-term cleanup action and/or immediate action to protect human health and the environment. The most seriously contaminated sites are proposed for placement on the NPL. "Proposed" NPL sites that meet the qualifications for cleanup under the Superfund Program become "final" NPL sites. Sites are considered for deletion from the NPL when all cleanup goals are met and there is no longer reason for federal action.

What the Data Show

As of October 1, 2002, there were 1,498 sites that were either final (1,233) or deleted (265). Of the 1,498 sites, 846 have completed all necessary cleanup construction. A construction complete site is a former toxic waste site where physical construction of all cleanup actions are complete, all immediate threats have been addressed, and all long-term threats are under control. An additional 62 sites were proposed in 2002 (Exhibit 3-30). The total number of NPL sites (including proposed) grew from 1,236 in 1990 to 1,560 in 2002. During this time period, the number of sites that have been cleaned up and have been transferred from "final" to "deleted" status have increased nearly 10-fold, from 29 in 1990 to 265 in 2002. In 2002, over 56 percent of the final and deleted sites were construction complete, compared to only four percent of the sites in 1990 (EPA, SERP, February 2003).

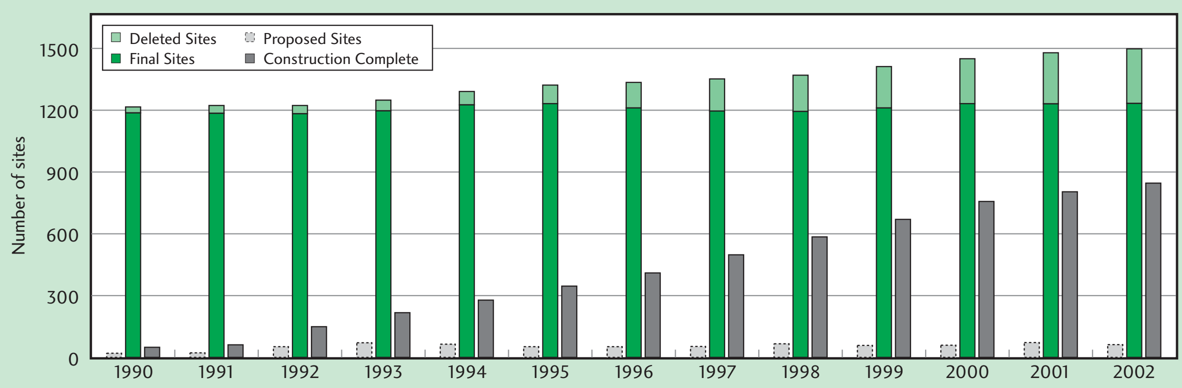
Indicator Gaps and Limitations

The NPL sites are tracked in CERCLIS. This database contains information on hazardous waste sites across the nation and U.S. territories including location, status, contaminants, and actions taken from 1983 to the present. The number of NPL sites provides a general indicator of contaminated lands, but these numbers do not translate directly to the extent of contaminated land. The NPL data cannot easily be used to clarify how many lands are contaminated because the NPL sites are divided into administrative groups (i.e., proposed, final, and deleted) that do not clearly describe whether the sites are currently contaminated. Additionally, there are many contaminated sites in CERCLIS that are not listed on the NPL, some contaminated sites are not in CERCLIS (e.g., are known only by local and state programs), and not all of the sites in CERCLIS are contaminated.

Data Source

The data source for this indicator is Comprehensive Environmental Response Compensation, and Liability Information System (CERCLIS) data, EPA Superfund Emergency Response Program, 1983-2002. (See Appendix B, page B-24, for more information.)

Exhibit 3-30. Superfund National Priorities List (NPL) site totals by status and



Note: "Construction Complete" sites include most "Deleted" sites and some "Final" sites.

Source: EPA, Office of Solid Waste and Emergency Response. National Priorities List Site Totals by Status and Milestone. March 26, 2003. (April 3, 2003; *http://www.epa.gov/superfund/sites/query/queryhtm/npltotal.htm*) and Number of NPL Site Actions and Milestones by Fiscal Year. March 26, 2003. (April 3, 2003; *http://www.epa.gov/superfund/sites/query/queryhtm/nplfy/htm*).

Indicator Number and location of RCRA corrective action sites - Category 2

Congress established the RCRA Corrective Action Program in 1984 because many hazardous waste management facilities were contaminated from current or past solid and hazardous waste management activities and required cleanup to protect humans and the environment. As with the Superfund Program, some sites subject to RCRA corrective action may be investigated and found to require little or no cleanup, while others may be found to have extensive soil, ground water, and/or sediment contamination.

What the Data Show

EPA estimates that approximately 3,700 hazardous waste management facilities may be subject to cleanup under the RCRA corrective action program (EPA, OSWER, October 2002). To date, EPA and authorized states have identified approximately 1,700 hazardous waste management facilities that are the most seriously contaminated and may pose significant threats to human health or the environment (EPA, OSWER, October 2002). These sites typically have both soil and ground water contamination and many also have contaminated sediments. Some RCRA corrective action sites are also identified by the Superfund Program as NPL sites.

Indicator Gaps and Limitations

RCRAInfo contains information about hazardous waste generators and management facilities in the U.S. and its territories. RCRAInfo includes data on site location, status, contaminants and contaminant sources, and actions taken. RCRAInfo provides reliable data about the number and location of RCRA corrective action sites and about cleanup priorities; however, information on cleanup status at sites is less reliable, particularly for lower priority sites. Cleanup status data for the 1,700 high priority sites is current—particularly with respect to ongoing exposures of humans to contamination and migration of contaminated ground water, the two site conditions that the RCRA corrective action program has chosen to track most closely. Also, there are overlaps between the list of high priority RCRA corrective action sites and NPL sites. Due to these overlaps, number-of-site comparisons between programs and simple counts of contaminated sites can be misleading.

Data Source

The data source for this indicator is EPA Office of Solid Waste and Emergency Response, RCRA Info Data, 1997-1999. (See Appendix B, page B-24, for more information.)

3.3.4 What human health effects are associated with waste management and contaminated lands?

While some types of waste (e.g., most food scraps) are not typically toxic to humans, other types (e.g., mercury) pose dangers to human health and must be managed accordingly. The number of substances that exist that can or do affect human health is unknown; however, the TRI program requires reporting of more than 650 chemicals and chemical categories that are known to be toxic to humans.

The EPA Superfund Emergency Response Program and the Agency for Toxic Substances and Disease Registry (ATSDR) have created useful lists of common contaminant sources and their potential health effects. Every 2 years, the ATSDR and EPA prepare a list, in order of priority, of hazardous substances that are most commonly found at the NPL sites and pose the most significant threat to human health due to their known or suspected toxicity and potential for human exposure (EPA, SERP, September 2002; ATSDR, 2001). Arsenic, lead, and mercury are the highest ranking substances on the list. All three of these substances are toxic to the kidneys, and lead and arsenic can cause decreased mental ability, weakness, abdominal cramps, and anemia (EPA, SERP, September 2002). Additional discussion of these substances is available in Chapter 4, Human Health.

EPA also maintains a separate list of common contaminants and their potential health effects. The list includes commercial solvents, household items, dry cleaning agents, and chemicals. With chronic exposure, commercial solvents such as benzene, can suppress bone marrow function and cause blood changes. Dry cleaning agents and degreasers contain trichloroethane and trichloroethylene, which can cause fatigue, depression of the central nervous system, kidney changes (e.g., swelling, anemia), and liver changes (e.g., enlargement). Chemicals used in commercial and industrial manufacturing processes such as arsenic, beryllium, cadmium, chromium, lead, and mercury, are toxic to kidneys. Long-term exposure to lead can cause permanent kidney and brain damage. Cadmium can cause kidney and lung disease. Arsenic, beryllium, cadmium, and chromium have been implicated as human carcinogens (EPA, SERP, September 2002).

Contaminants can come into contact with humans through three exposure pathways: inhalation, ingestion, and direct contact. Exposure routes can vary for each substance. Chemicals can contaminate ground water due to leaking tanks, runoff, and leaching through soil or sediment. In addition, the cleanup of sites contaminated with radioactive materials has involved the remediation of approximately 1.7 trillion gallons of ground water—an amount equal to four times the U.S. daily water consumption (DOE, 2000).

Information on waste generation amounts alone does not lead to a complete understanding of the effects of waste on people and the environment. The specific risks and burdens differ substantially from waste type to waste type. For example, one pound of grass clippings is not "equal" in terms of potential risk in exposure to one pound of dioxin. Exposure to waste is likely to vary as a function of management practices: treatment, storage, transfer, and disposal actions. Waste that is efficiently and safely treated and disposed of is likely to have relatively little effect on human health. No specific indicators have been identified at this time. Additional discussion of the human health effects associated with waste management and contaminated lands is found in Chapter 4, Human Health.

3.3.5 What ecological effects are associated with waste management and contaminated lands?

Hazardous substances can have negative effects on the environment by degrading or destroying wildlife and vegetation in contaminated areas, causing major reproductive complications in wildlife, or otherwise limiting the ability of an ecosystem to survive. Certain hazardous substances also have the potential to explode or cause a fire, threatening both wildlife and human populations (EPA, SERP, September 2002).

Waste from extraction activities can contaminate water, soil, and air; affect human health; and damage vegetation, wildlife, and other biota. Toxic residues left from mining operations can be transported into nearby areas, affecting resident wildlife populations. This type of damage is often the result of unlined land-based units that have minimal release controls. These units include surface impoundments containing mill tailings and/or process wastewater, heap-leaching solution ponds, dusts, piles of slags, refractory bricks, sludge, waste rock/overburden, and spent ore. Spills and leaks from lined management units, valves, and pipes also are known to occur.

Contaminated lands can pose a threat depending on several factors such as site characteristics and potential exposure of sensitive populations. The negative effects of land contamination on ecosystems and wildlife occur after contaminants have been released on land (soil/sediment) or into the air or water. Often, land contamination leads to water or air contamination by means of gravity, wind, or rainfall. No specific indicator was identified at this time.

3.4 Challenges and Data Gaps

Many of the specific data gaps related to development of the described indicators and their ability to answer the questions posed have already been identified. The discussion below augments the previously identified gaps.

3.4.1 Land Use

The ability to accurately characterize and track land use over time is limited. Various federal efforts, such as the USDA NRCS, NRI, the USDA Forest Service FIA, the U.S. Fish and Wildlife Service (USFWS) Status and Trends Program, and the NLCD, contribute in part to tracking some land uses and a variety of cover types. None of these are comprehensive for all lands or land uses, and some have limitations in their frequency of data collection or analysis. Some cover types and land uses are not sampled in any detail, including private and federal desert lands, federal shrublands and grasslands, and rangeland. In addition, Alaska is seldom included in national inventories, although Alaska represents approximately 16 percent of the land area of the U.S. and includes extensive shrublands, grasslands, and tundra.

Each of the national systems has developed different methods, definitions, and classification criteria. While some effort has been made to share definitions across some of these systems (e.g., the NRI and FIA systems use essentially the same definition of forest land, and NRI and FWS define wetlands similarly), not all are consistent, especially in descriptions of developed or urban land, cropland, and rangeland. Examples of differences in classifications and acreage from several current national efforts are shown in Exhibit 3-31 for developed and agricultural land uses. The NLCD uses different classification and land use definitions because it is based on remote sensing data (an aerial perspective) rather than on ground sampling. FWS information is also based on aerial photo interpretation. Given the increasing availability of high resolution aerial imagery, remotely sensed techniques for land cover delineations are likely to increase and classifications based on this inventory approach should be coordinated and defined.

Another challenge is developing data on uses and cover types that at present are not adequately sampled. Further challenges include effectively integrating and harmonizing the various results of multi-agency, as well as state and local, efforts and coordinating the limited resources dedicated to national tracking of land cover/land use changes among agencies, so that inventories can be performed as frequently and as comprehensively as possible. The overarching goal is to assess national patterns in such a way that changes in land cover and land use that might have implications for human health or ecological condition can be detected and addressed.

Exhibit 3-31: Land cover/land use estimates

Data Source	Developed Land	Agricultural Land
National Resources Inventory (NRI)[A]	98 million acres developed land	377 million acres cropland 32 million acres Conservation Reserve Program land 120 million acres pastureland
The Heinz Center[B]	32 million acres urban and suburban land	430-500 million acres cropland, hayland, and pastureland
U.S. Census Bureau[C]	47 million acres urbanized areas 13 million acres urban clusters	No data
National Land Cover Data (NLCD)[D]	36.7 million acres low and high density residential and commercial/industrial/ transportation	331 million acres cropland 179 million acres pastureland and hayland

Note: The NRI, Heinz Center, and NLCD sources do not include Alaska as part of the estimates.

[A] USDA, Natural Resources Conservation Service. *Summary Report: 1997 National Resources Inventory (Revised December 2000)*. 2000.
[B] The Heinz Center. *The State of the Nation's Ecosystems*. 2002.
[C] U.S. Census Bureau. Corrected Lists of Urbanized Areas and Urban Clusters. November 25, 2002. (March 2003; *http://www.census.gov/geo/www/ua/ua_state_corr.txt and http://www.census.gov/geo/www/ua/uc_state_corr.txt*).
[D] USGS, National Land Cover Dataset. NLCD Land Cover Statistics. 2001. (March 2003; *http://landcover.usgs.gov/nlcd.html*).

The data available that actually summarize a national picture of land use are extremely limited. Relatively little comprehensive information exists about federal land management practices and extent. For example, while the USDA Forest Service tracks acres managed for timber production, data are not easily accessible on acres used for grazing; oil, gas, and mineral development; or recreation. Data needed to summarize all lands under some form of "protection," such as parks, wilderness areas, reserves, or conservation easements at all levels of government, do not exist.

In many cases, where land is used to produce food or fiber, indicators that report the amounts and values of these commodities might be used to identify the condition/stress/pressure on the land. Examples of commodities include agricultural products, forest products, and cattle produced from grazing land. The amount of fresh water used by humans might also be a good indicator of the pressure being applied to land and water resources. Commodity production is commonly correlated closely to population growth. Reporting of commodity production trends in agriculture and forestry might also provide another view of the effects of these activities on the land and help evaluate policy options for ensuring long term, sustainable commodity production while reducing environmental effects.

Land provides many other benefits in addition to commodity production. Research is being conducted on the subject of quantifying these "ecosystem services." Indicators are needed that will enable measuring and tracking some of these services.

3.4.2 Chemicals

Most of the national efforts to track chemical usage focus on how much is produced, used, or released, with less emphasis on tracking the extent or area of use. The TRI database requires reporting of releases of certain volumes of specific chemicals, but aside from knowing the location of initial releases, it does not track the extent of the area that might in some way be affected by the chemicals. In addition, pesticide and fertilizer use are primarily tracked by understanding where these chemicals are sold, rather than where they are actually used.

Further, not all toxic chemicals are on the list of TRI chemicals and, therefore, some toxics are not reported. The TRI program faces the challenge of maintaining a current list that reflects the constant development, use, and release of new chemicals that might have effects on human and ecological health.

Indicators for pesticide residue in food, potential pesticide runoff from farmlands, risk of nitrogen runoff, and risk of phosphorus runoff all address some part of the question of potential chemical disposition. Only the indicator for pesticide residues in food, however, goes beyond stating the potential for chemicals to leave their point of use and actually shows the potential for consumers to be exposed to these chemicals. Indicators to better understand the actual disposition of chemicals, rather than potential disposition, would be useful to correlate with actual human health and ecological condition indicators.

State Pesticide Use Reporting Systems

While there is no national pesticide use reporting system, several state systems exist. For example, California, with the most advanced system in the country, has had full pesticide use reporting since 1990. Reports about the specifics of application are filed by large- and small-scale farmers, commercial agricultural pesticide applicators, structural pest control companies, and commercial landscaping firms. (California Department of Pesticide Regulation, 2000.)

Better indicators of the linkages between chemical applications on the landscape and chemicals that find their way into the bodies of humans and other species are needed. This includes better information on the chemistry, quantities, and longevity of various substances; on the cumulative effects of various chemicals on the environment and humans; and on the pathways and effects of exposure. In cases where nutrients do reach receiving waterbodies and raise the concentrations above background levels, considerable uncertainty still exists concerning ultimate ecological effects. Current research does not clearly quantify the relationship between raised nutrient levels and resulting ecological changes.

Better information is needed to provide an accurate picture of the human health effects of pesticide use. This information is difficult to collect, however. Even in California, where significant resources are dedicated to pesticide regulation, the best available indicator is a measure of reported illnesses and injuries from pesticide exposure in the workplace. While this is valuable information, it does not address potential long-term health effects of non-workplace exposure that might result through drinking water and food exposure.

3.4.3 Waste and Lands Used for Waste Management

Several challenges and data gaps limit the understanding of waste and its effects on human health and ecological condition. First, as noted, waste data tend to be developed in response to the requirements of specific mandates or regulations. Because these regulations do not apply to all types of waste and are carried out at different levels of government, and in the private sector, complete data do not exist to answer the question: "How much waste is generated?" Additionally, most waste generation is reported only by weight, providing little understanding of the volume of waste produced.

Information about the amount of waste generated does not provide a complete picture on either the extent of waste-related problems or the effects of waste on human health, ecosystems, or the ambient environment. Different waste types pose substantially different types of risks. Some wastes are known to be hazardous to humans and the environment, but specifics about exposures and the effects of many other waste types are not well understood and data are limited. Finally, the risks posed by waste are largely a function of the type and effectiveness of waste management. The available data on waste and waste management have been limited by the stringent regulatory requirements and definitions that have driven most of the national information collection efforts.

Data to describe how lands are affected by waste management are also limited. Even basic statistics on the acreage of lands used for managing waste and the condition of those lands are not available at the national level. To gain a more complete understanding of the extent and effects of land used for waste management would require information on waste management methods, standards, and compliance, as well as information on lands where illegal dumping occurs. Establishing linkages to human populations or ecosystems within close proximity to lands managed for waste is an additional challenge.

3.4.4 Contaminated Land

Today, the best available information used to describe extent of contaminated land includes measures of the number and location of sites. two indicators of contaminated land that lack national-quality data are the extent of contaminated land and the effects of contamination.

Determining the extent of contaminated land would require national-level information on the number, location, and area of contaminated lands, and data on the specific site contaminants and the associated risks, hazards, and potential exposures. Additional factors such as the potential contamination of ground water sources and the transportation or disposal methods needed to clean up the contamination would have to be considered. Such data are currently captured for only a subset of the nation's contaminated lands. In addition, information on known contaminated lands (e.g., some sites in EPA's Comprehensive Environmental Response, Compensation, and Liability Information System) that are not on the Superfund's NPL, data in state and local databases, and information on the other types of contaminated lands (e.g., leaking underground storage tanks) are not captured in the existing data.