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# Urban and Suburban Areas





## Urban and Suburban Areas

### What Indicators Are Used To Describe Urban and Suburban Areas?

Can we report trends? Are there other useful reference points?

#### SYSTEM DIMENSIONS

●	Area of Urban and Suburban Lands	How much land do “urban and suburban areas” occupy? How much of this land is developed, and how much is forest, grasslands and shrublands, wetlands, and croplands?	Current data only, regional comparison
?	Suburban/Rural Land Use Change	How are patterns of development changing at the boundary between suburban and rural areas?	No data reported
●	Patches of Forest, Grassland and Shrubland, and Wetlands	How large are urban/suburban forests, grasslands and shrublands, and wetlands, which provide green space and wildlife habitat?	Current data only, regional comparison
⊖	Total Impervious Area	How much urban/suburban land is covered with buildings, concrete, asphalt, and other “hard,” or impervious, surfaces?	No data reported
?	Stream Bank Vegetation	What fraction of urban/suburban stream banks are vegetated?	No data reported

#### CHEMICAL AND PHYSICAL CONDITIONS

●	Nitrate in Urban and Suburban Streams	How much nitrate is found in urban/suburban streams?	Current data only, federal standard
●	Phosphorus in Urban and Suburban Streams	How much phosphorus is found in urban/suburban streams?	Current data only, federal goal
●	Air Quality (High Ozone Levels)	How common are air pollution levels that exceed federal guidelines in urban/suburban areas?	Trends, federal standard
Ⓛ	Chemical Contamination	What levels of artificial compounds and heavy metals are found in water and soil?	Current data only, federal standards and guidelines
?	Urban Heat Island	How much hotter are urban/suburban areas than less-developed areas nearby?	No data reported

#### BIOLOGICAL COMPONENTS

⊖	Species Status	How many of the plants and animals that once inhabited areas that are now urban/suburban are locally at risk or absent?	No data reported
⊖	Disruptive Species	Are there more or fewer “disruptive species” such as white-tailed deer and Scotch broom in urban/suburban areas?	No data reported
⊖	Status of Animal Communities in Urban and Suburban Streams	What is the condition of fish and bottom-dwelling animals in urban/suburban streams?	No data reported

#### HUMAN USES

⊖	Publicly Accessible Open Space per Resident	How much public open space is there per urban/suburban resident?	No data reported
?	Natural Ecosystem Services	What other important ecosystem services are provided by urban/suburban areas?	No data reported

● All Necessary Data Available    Ⓛ Partial Data Available    ⊖ Data Not Adequate for National Reporting    ? Indicator Development Needed



## Chapter 10:

# Indicators of the Condition and Use of Urban and Suburban Areas

Thinking of America's cities and suburbs as an ecosystem does not come automatically to many people. "Ecosystems" are usually defined by plants, animals, naturally occurring attributes like landscape type, and the interaction among these elements. People, by contrast, create cities and suburbs, and it is the built environment—houses, office buildings, factories, roads, sidewalks, piers, parking lots—that defines them. Although they occupy less than 2% of the land area of the lower 48 states, cities and suburbs are home to more than 75% of all Americans. Characterized by a great many people living in a very small area, much of it covered by a variety of hard surfaces, cities and suburbs nevertheless provide a range of goods and services not unlike those provided by the other, more "natural," ecosystems. In fact, 20% of urban and suburban land is forest, farmland, wetlands, or grassland and shrubland; streams run through cities and suburbs, and many cities lie on the coast. It is in this unconventional ecosystem that people interact most often with nature.

### What can we say about the condition and use of urban and suburban areas?

Fifteen indicators describe the condition and use of urban and suburban areas. Partial or complete data are available for six of these indicators. Only one (air quality) has a long enough data record to judge trends, while four can be compared to a regulatory standard or guideline. For five indicators, data are not available for reporting on a national basis, and four indicators require additional development before it will be possible to assess the availability of data.

After the following brief summaries of the findings and data availability for each indicator, the remainder of this chapter consists of the indicators themselves. Each indicator page offers a graphic representation of the available data, defines the indicator and explains why it is important, and describes either the available data or the gaps in those data.

### System Dimensions

Five key indicators describe the dimensions of the urban/suburban system. The first and most basic is how much land these areas occupy, and how much is developed or remains as forest, grassland or shrubland, or other undeveloped land. A second indicator, still requiring development, would track conversion of land from rural to suburban. Three other indicators provide further detail on the character of urban and suburban lands. One tracks the size of the patches of forest, grasslands and shrublands, and other natural areas that provide green space and wildlife habitat; a second tallies the fraction of urban and suburban lands covered by asphalt, buildings, and other impervious surfaces that prevent the penetration of rainfall and on which plants cannot grow. A final measure will track the percentage of urban streams that are lined with vegetation, which can have a significant effect on water quality and which also serves as wildlife habitat.

- **How much land do "urban and suburban areas" occupy? How much of this land is developed, and how much is forest, grasslands and shrublands, wetlands, and croplands?** In 1992, urban and suburban areas, as defined by this report, accounted for about 32 million acres in the lower 48 states, or about 1.7% of total land area. About 22% of urban and suburban land in the South, Northeast, and West was undeveloped; in the Midwest, this figure was 17%.
- **How are patterns of development changing at the boundary between suburban and rural areas?** When suburban development expands into rural areas, the pattern of development—how dense or spread out it is; how transportation, water, sewer, and other infrastructure are integrated, and so



on—can affect both wildlife and people living in and around newly developed areas. This indicator requires further development.

- **How large are patches of “natural” lands (forests, grasslands and shrublands, and wetlands), which provide green space and wildlife habitat?** Natural lands are important for urban and suburban recreation and quality of life, and they are also important as wildlife habitat. The value of these patches for both people and wildlife can be affected by their size. About half of all natural lands in urban and suburban areas are in patches smaller than 10 acres. A progressively smaller percentage are found in larger patches—nationally, less than 5% of urban/suburban natural lands are found in patches of 1,000 acres or more.
- **How much of urban and suburban areas is covered with buildings, concrete, asphalt, and other “hard,” or impervious, surfaces?** Places that have a higher percentage of impervious surfaces often have more, and dirtier, runoff, than places with less “hard” surface. Data are not adequate for national reporting on this indicator.
- **What fraction of urban and suburban stream banks are vegetated?** Vegetation along streams can reduce the effects of runoff and serve as wildlife habitat. This indicator requires further development.

### Chemical and Physical Conditions

As is the case for several of the other systems, many of the indicators of chemical and physical condition of urban and suburban areas focus on streams. Because streams receive runoff from the land surface, they are powerful indicators of conditions on that land surface. Two indicators track concentrations of nitrate and phosphorus, nutrients that can, in excess, cause problems. A third indicator tracks contaminants such as pesticides, PCBs, and heavy metals in stream water and soils, while a fourth tracks urban air quality, particularly concentrations of ozone, a key component of smog. Finally, one indicator, requiring further development, tracks the differences in temperature between cities and their surrounding regions.

- **How much nitrate is there in urban and suburban streams?** Nitrate is an important plant nutrient, but it also contributes to water quality problems. Nitrate in drinking water is a health threat for young children, and it must be removed at significant cost by municipalities that rely on river water. Sources of nitrate include sewage treatment plants, animal wastes, and fertilizers. About 60% of urban and suburban stream sites tested have concentrations of nitrate below 1 part per million (ppm); all samples were below the federal drinking water standard of 10 ppm. No trend data are available, but nitrate levels are lower in urban/suburban streams than in streams in agricultural areas, but higher than in forest streams.
- **How much phosphorus is there in urban and suburban streams?** About two-thirds of urban and suburban stream sites had phosphorus levels of at least 0.1 part per million, the upper limit recommended by the Environmental Protection Agency to prevent nuisance algae growth in fresh waters. Phosphorus concentrations in urban and suburban streams are similar to those in farmland streams, and much higher than those in forest streams. Sources of phosphorus in urban streams include sewage treatment plants, animal wastes, some detergents, and fertilizers.
- **How common are air pollution (ozone) levels that exceed federal guidelines in urban and suburban areas?** In 1999 about 55% of monitoring stations in urban and suburban areas recorded high ozone levels on at least 4 days, a number that generally triggers violations of federal air quality regulations. Throughout the 1990s, about 50% of monitoring stations recorded high ozone levels on at least 4 days each year. During the same period, the number of monitors recording high levels on 25 or more days per year declined, to about 5% in 1999.
- **What levels of contaminants (primarily artificial compounds and heavy metals) are found in stream water and soil?** All urban and suburban stream sites had at least one chemical that exceeded guidelines for protection of aquatic life, and 5% of sites had contaminants that exceeded human health standards or guidelines. About 85% of stream sites in urban and suburban areas had an



average of at least five detectable contaminants throughout the year. Data are not adequate to report on contamination in soils in urban and suburban areas.

- **How much hotter are urban and suburban areas than less developed areas nearby?** Asphalt, concrete, and other constructed materials in developed areas absorb solar energy, often leading to higher temperatures than in undeveloped areas. This can raise summertime cooling costs and cause human health problems where air conditioning is not available. This indicator requires further development.

### Biological Components

The biological condition of urban and suburban regions is captured by three indicators. The first reports the percentage of presettlement species that are now rare or missing from urban areas. The second tracks the number of disruptive species, like white-tailed deer and Tartarian honeysuckle. The third indicator, also used in the freshwater system, compares the fish and bottom-dwelling communities in urban and suburban streams to those in relatively undisturbed streams.

- **How many of the plants and animals that once inhabited areas that are now urban and suburban are locally at risk or absent?** Conversion of land from rural to urban or suburban is often accompanied by declines in the populations of native plants and animals or loss of species. These declines and losses may be influenced by the kind and amount of development, and by how sensitive different species are to disruption. Data are not adequate for national reporting on this indicator.
- **Are there more or fewer “disruptive species,” like white-tailed deer and Scotch broom, in urban and suburban areas?** Disruptive species are those that—whether they are native or non-native—cause problems for people, property, or wildlife. For example, deer are so numerous in some suburban areas that damage to gardens, car accidents, and increased incidence of Lyme disease have become serious political, health, and safety issues. Data are not adequate for national reporting on this indicator.
- **What is the condition of fish and bottom-dwelling animals in urban/suburban streams?** Modifying a stream, through pollution, changes to the streambed or bank, flow modification, or other means can change the number and diversity of fish and bottom dwelling animals. Data are not adequate for national reporting on this indicator.

### Human Use

Natural areas in cities and suburbs provide many benefits to people. The most basic measure of the potential for such benefits is the amount of public open space per resident. A second indicator would tally natural ecosystem services, such as purifying air and water, lowering energy consumption, and reducing stormwater runoff.

- **How much public open space is there per urban/suburban resident?** Open space is valued by many urban dwellers for recreation and general “quality of life” reasons. Data are not adequate for national reporting on this indicator.
- **What other important natural ecosystem services are provided by urban and suburban areas?** Undeveloped lands provide a variety of services of value to people, including purification of stormwater by forested areas and wetlands and cooling and noise reduction by shade trees. This indicator requires further development.

### What do we mean by the “urban and suburban ecosystem”?

Urban and suburban areas are those places where most of the land is devoted to buildings, houses, roads, concrete, grassy lawns, and other elements of human use and construction.

This system spans a range of density, from high-rise-dominated downtowns to the suburban fringe, where residential tract development gradually thins to a rural landscape. This transition is neither



smooth nor uniform. At this outer edge, new developments—some quite dense—may appear in otherwise rural areas and leave intervening areas undeveloped, at least for a time.

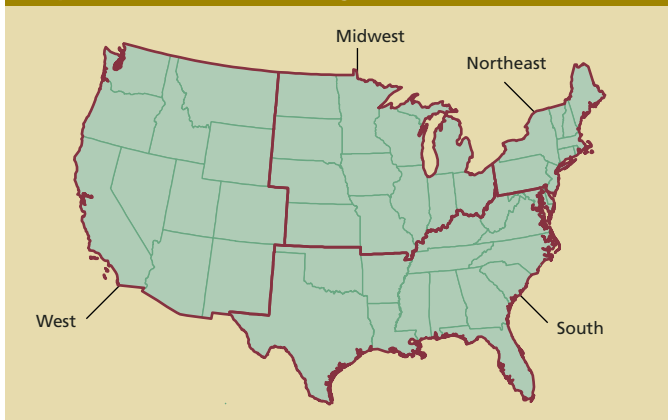
This report uses a newly developed approach to define urban and suburban lands. It relies upon the physical characteristics of the land, rather than population density, as is commonly done, and employs two basic criteria. First, a substantial portion of the land must be covered with buildings, roads, concrete, and the like, and second, these areas must be sufficiently large (about 270 acres or more) to be considered “urban / suburban.” This method excludes scattered or isolated areas such as small settlements, large parking lots, or single residences, but includes large “natural” areas, such as city parks, which are surrounded by otherwise-urban lands. Details of the methods used for identifying these areas are provided in the Area of Urban and Suburban Lands technical note (p. 264).

### A Note about Undeveloped Lands in Urban and Suburban Areas

Three indicators describe undeveloped urban and suburban lands (Area of Urban and Suburban Lands; Patches of Forest, Grassland and Shrubland, and Wetlands; and Publicly Accessible Open Space per Resident). Since these indicators focus on different aspects of undeveloped land, they count different types of such lands. In the Area of Urban and Suburban Lands indicator (p. 181), we classify forests, croplands (including pastures), grasslands and shrublands, and wetlands as “undeveloped lands.” In the Patches of Forest, Grassland and Shrubland, and Wetlands indicator (p. 183), we focus on “natural” lands, a subset of undeveloped lands that includes forests, grasslands and shrublands, and wetlands, but not croplands or pastures. Finally, in the per capita open space indicator (p. 194), we report on all lands that are publicly accessible, as long as they are not paved. This includes publicly accessible forests, grasslands and shrublands, and wetlands (natural lands), but also areas such as parks with manicured

lawns, ballfields, beaches, and the like. Farms, which provide significant amounts of open space in many areas, are generally privately owned and not typically accessible to the general public.

Map 10.1. Census Bureau Regions



### A Note about Regions

Two indicators—Area Of Urban and Suburban Lands (p. 181) and Patches of Forest, Grassland and Shrubland, and Wetlands (p. 183)—are reported on the basis of multistate regions adopted by the Census Bureau (Map10.1). While the data presented for these indicators do not include Alaska and Hawaii, the Census Bureau includes these states in the

Western region; when data on Alaska and Hawaii become available, future reports will include them in this region. The air quality indicator is presented in map form. Several other indicators would, if data were available, also be presented in regional or map form.

Finally, many of the indicators included in this report would probably require local financial resources and expertise, which may not be available for all areas meeting the “urban and suburban” definition we used. Therefore, several indicators—Urban Heat Island (p. 190) and Species Status (p. 191), among others—are presented on the basis of the “percent of all metropolitan areas,” which is intended to imply that the reporting will be focused on major cities and their surrounding areas. Implementing these indicators might best be achieved by identifying a suite of metropolitan areas (perhaps defined by size or population) to serve as the basis for national and regional reporting.



SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants Physical	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ● Area of Urban and Suburban Lands

### What Is This Indicator, and Why Is It Important?

This indicator reports the extent of urban and suburban lands, both in acres and as a percentage of all land area in a region; it also reports on the extent and composition of undeveloped lands, such as wetlands, croplands, forest, or grassland and shrubland, contained within urban and suburban areas.

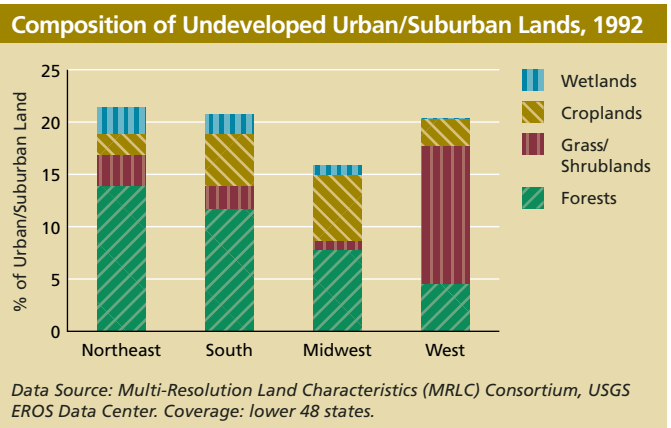
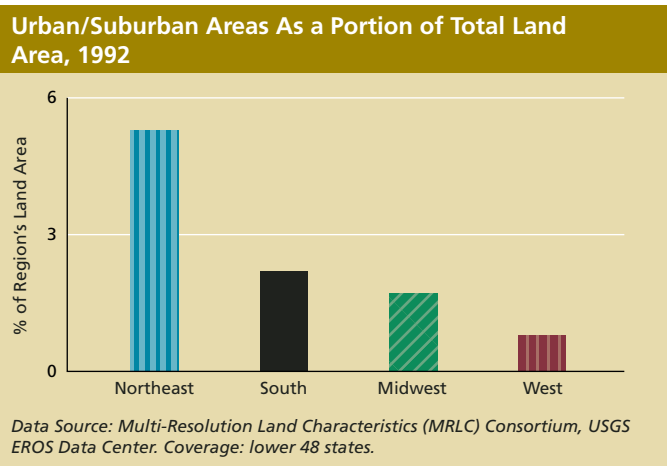
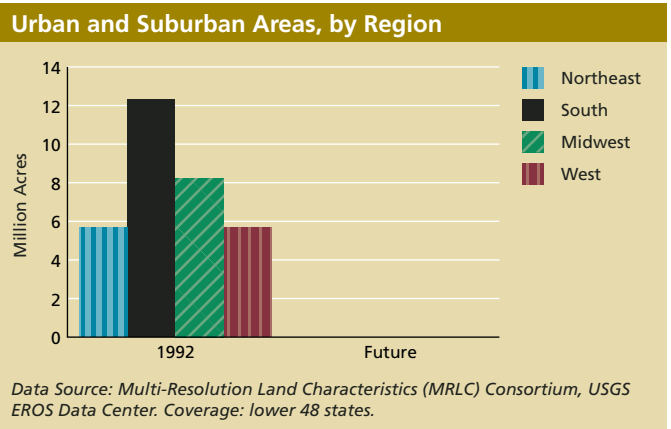
About 75% of all Americans live on land that is urban or suburban in character, which is less than 2% of the lower 48 states. Increases in urban/suburban area are generally permanent and may affect the use and character of surrounding lands (see the land use change indicator, p. 182). Describing the amount and composition of undeveloped lands provides a coarse view of how intensely developed urban and suburban lands are, which is related to the amount and type of open space available to a region's residents (see p. 194), the extent of impervious surfaces (see p. 184), and the services provided by the "natural" systems in urban and suburban areas (see p. 195).

**What Do the Data Show?** In 1992, urban and suburban areas occupied 32 million acres in the lower 48 states, or 1.7% of total land area. Most of the land designated urban or suburban is in the South and Midwest, but cities and suburbs account for less than 2% of the land area in those regions. In comparison, urban and suburban lands in the Northeast made up over 5% of the landscape.

The South, Northeast, and West had nearly identical percentages of undeveloped land within their urban and suburban areas (about 22%), while the Midwest had less (17%). In the Northeast and South, forests dominate these undeveloped areas; in the Midwest, farmlands dominate, and in the West grasslands and shrublands dominate.

**Discussion** The definition of urban and suburban areas used here is fairly restrictive. It focuses on highly urbanized areas and their surrounding suburbs, plus developed outlying areas above a minimum size. It covers residential areas, commercial and industrial areas, parks and golf courses, and the like. It is not delineated on the basis of jurisdictional boundaries, but rather on actual land cover as identified using satellite data, and can be applied repeatedly over time. Other programs (see technical note), such as those that tally all developed lands, whether or not they are sufficiently aggregated to be considered "suburban," identify more developed lands than are reported here.

The technical note for this indicator is on page 264.





SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent	Nutrients, Carbon, Oxygen	Plants and Animals	Food, Fiber, and Water
Pattern	Contaminants Physical	Communities Ecological Productivity	Recreation and Other Services

## ② Suburban/Rural Land Use Change

**Suburban/Rural Land Use Change**

Indicator Development Needed

### What Is This Indicator, and Why Is It Important?

This indicator will describe the pattern and intensity, or density, of development, both at the outer edge of suburban development around cities, and in rural areas that, despite the lack of a large town center, are growing rapidly toward suburban densities.

Citizens and policymakers alike have expressed strong interest in the nature and pace of suburban development. Patterns of development can directly affect wildlife and the people living in and around newly developed areas. Concerns often focus on the conversion of natural or agricultural land to low-density housing or commercial development, often accompanied by loss of

open space; demands for more roads and sewers; increased crowding in public schools; and longer travel times to jobs and stores. Landowners, however, often resist efforts to control or channel development, and some jurisdictions favor continued growth as a means of ensuring steady or increasing tax revenues.

**Why Can't This Indicator Be Reported at this Time?** Reporting on this indicator will require agreement among land use professionals on the most appropriate measure of changes in suburban and rural land use, and on monitoring of these changes using consistent methods.

Public debate often focuses on “sprawl” or “smart growth,” but there is no consensus on how best to measure—and thus to track—these phenomena. Issues include change in overall density, the appropriate mix of commercial and low- and high-density housing, and the degree to which new development is located near existing development or in more remote undeveloped areas.

One type of candidate indicator focuses on the degree to which patches of forests, grasslands, and wetlands are reduced in size and isolated from each other, affecting the amount of wildlife habitat and open space values they provide (see the “natural area” patches indicator, p. 183, the open space indicator, p. 194, and the ecosystem services indicator, p. 195). Another approach focuses on such issues as the amount of time residents spend traveling to stores, jobs, and schools, perhaps measured in vehicle-hours.

There is no technical note for this indicator.



SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent	Nutrients, Carbon, Oxygen	Plants and Animals	Food, Fiber, and Water
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## ● Patches of Forest, Grassland and Shrubland, and Wetlands

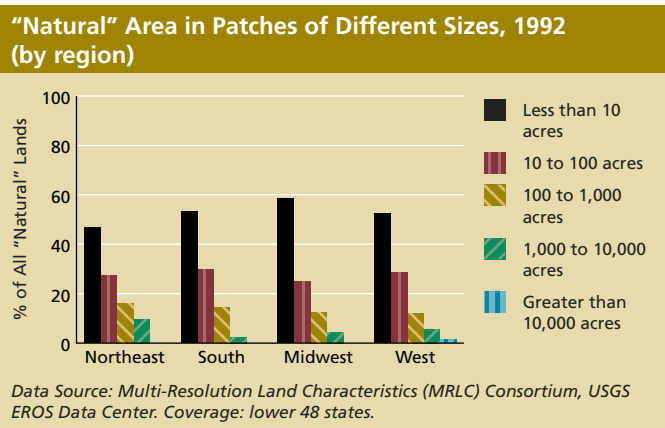
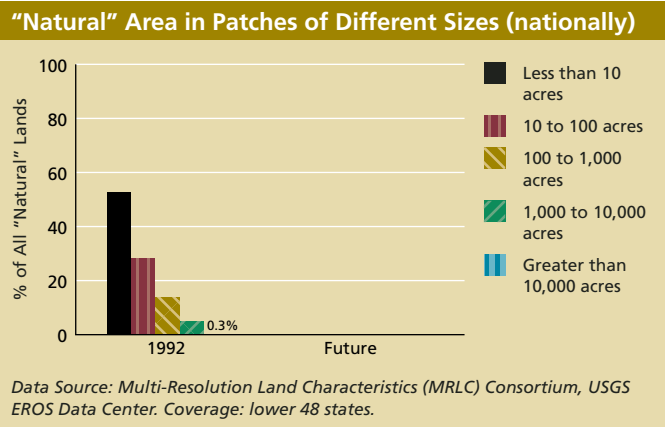
**What Is This Indicator, and Why Is It Important?** This indicator reports how much of the “natural” area within urban and suburban lands is in patches of varying size, from less than 10 acres to greater than 10,000 acres. Natural areas include forests, grasslands and shrublands (including most pasturelands—especially in the west), and wetlands.

Smaller patches of natural habitat generally provide lower-quality habitat for plants and animals (although this is not necessarily true for wetlands) and provide less solitude and fewer recreational opportunities for people. Smaller patches of habitat favor common, human-tolerant species like squirrels, white-tailed deer, starlings, and sparrows, over less common species that require larger areas, such as some birds (pileated woodpeckers, broad-winged hawks, and many warblers), mammals (bears, mountain lions, wolves, coyotes, mink, otters, and weasels), and amphibians.

**What Do the Data Show?** About half of all natural lands in urban and suburban areas are in patches smaller than 10 acres. A progressively smaller percentage of natural areas are found in larger patches, so that, nationally, less than 5% of the total is found in patches of 1,000 acres or more. The Northeast has a higher percentage of large “natural” patches (100 to less than 1,000 acres and 1,000 to less than 10,000 acres) than the other regions, while very large patches (greater than 10,000 acres) are found only in the West; these patches account for 0.3% of all natural lands in urban and suburban areas.

**Discussion** In addition to size (shown here), the quality of habitat and recreational value of natural areas is influenced by other factors, such as the shape of patches and how isolated they are from other natural areas.

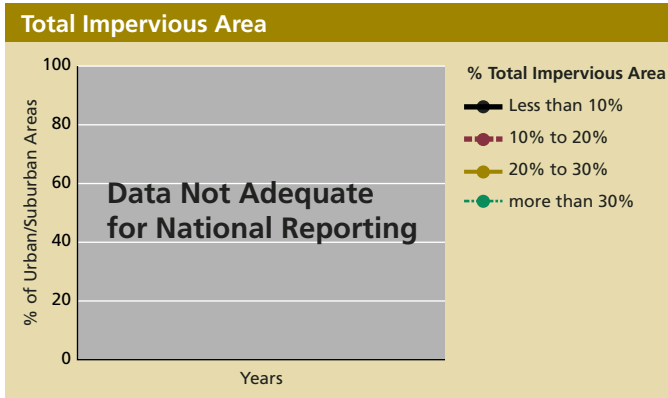
The technical note for this indicator is on page 266.





SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants Physical	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ⊖ Total Impervious Area



### What Is This Indicator, and Why Is It Important?

This indicator classifies urban and suburban areas according to the percentage of impervious surface—roads, parking lots, driveways, sidewalks, rooftops, and the like—they contain. The indicator uses several thresholds: less than 10% impervious surface in the region, at least 10%, at least 20%, and at least 30%.

The amount of impervious surface is a direct measure of the degree of urbanization, and it strongly affects both water quality in urban and suburban areas and replenishment of groundwater. Areas with more impervious, or nonporous, surfaces generate more runoff,

which not only can contaminate and warm stream waters but also can degrade stream channels and banks. These changes have major impacts on the fish and wildlife that inhabit streams. In general, the impact on streams increases as the percentage of impervious surface in a watershed increases.

**Why Can't This Indicator Be Reported at This Time?** Total impervious area is difficult to measure. Measurements must be made on a fine scale to account for small areas such as sidewalks and driveways, but the finest-scale satellite information generally available cannot distinguish features of this size. Many local planning and environmental management programs collect this information, but the data have not been compiled regionally or nationally, nor are there standard methods for estimating the amount of impervious surface.

The technical note for this indicator is on page 266.



SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants Physical	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ? Stream Bank Vegetation

**What Is This Indicator, and Why Is It Important?** This indicator will describe the percentage of miles of stream (stream-miles) in urban and suburban areas that are lined with trees, shrubs, and other plants.

The amount of vegetation along a stream bank strongly affects both water quality and the kinds of fish and other animals that live in and along the stream. Plants lining a stream bank shade the stream, making it cooler in summer, and they serve as habitat for animals. Plants drop leaves and branches into the stream, providing food and habitat for stream animals; they also trap sediments and pollutants washing in from adjacent areas, preventing them from reaching the water and helping to maintain good water quality.

**Stream Bank Vegetation**

Indicator Development Needed

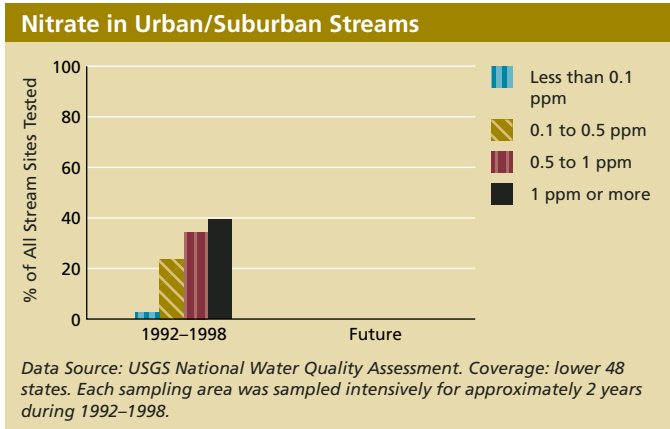
**Why Can't This Indicator Be Reported at This Time?** Reporting on this indicator would require agreement on a standard approach for defining and measuring streamside vegetation, including the minimum width of plant cover for a stream to be considered “vegetated,” and agreement on whether and to what degree “unnatural” plant cover such as lawns should be counted. Once such definitions are established, data sources could be evaluated. These include satellite-based measures, which currently cannot distinguish very small landscape features, and locally generated information, which can be quite detailed, although it may be incompatible from location to location and very expensive to obtain.

There is no technical note for this indicator.



SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	<b>Nutrients, Carbon, Oxygen</b> Contaminants Physical	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ● Nitrate in Urban and Suburban Streams

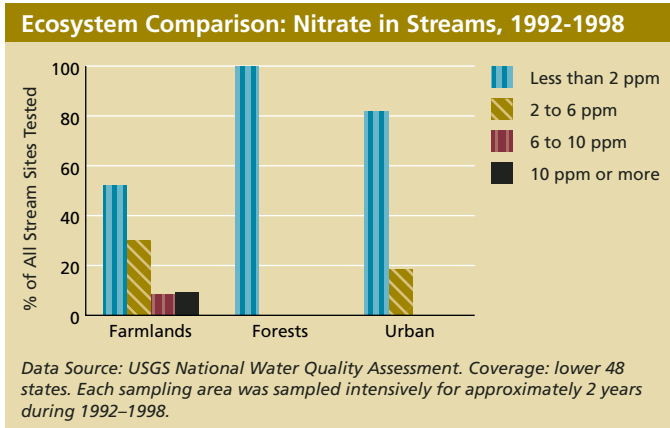


### What Is This Indicator, and Why Is It Important?

This indicator reports the concentration of nitrate in streams in representative urban areas. Specifically, the indicator reports the percentage of streams with average nitrate concentrations in one of four ranges, for streams draining watersheds that are primarily urban.

Nitrate is a naturally occurring form of nitrogen and an important plant nutrient; it is often the most abundant of the forms of nitrogen that are readily usable by plants, including algae. Increased nitrate in streams that ultimately empty into coastal waters can lead to algal blooms in those waters; these blooms decrease recreational and aesthetic values and help deplete oxygen needed by fish and other animals (see the national nitrogen indicator and the hypoxia indicator, pp. 46 and 71). Nitrate in drinking water is also a health threat for young children, and it must be removed at significant cost by municipalities that rely on river water.

Sources of nitrogen in urban streams include effluent from sewage treatment plants, animal wastes, and fertilizers used on lawns, gardens, golf courses, and agricultural fields.



**What Do the Data Show?** About 60% of the stream sites in areas dominated by urban and suburban land use had concentrations of nitrate below 1 part per

million, about 25% had concentrations below 0.5 part per million (ppm), and about 3% had concentrations that were less than 0.1 ppm. The federal drinking water standard for the protection of human health is 10 ppm of nitrate, which is exceeded in streams only in agricultural areas.

Concentrations in streams in areas dominated by urban land use are lower than those from agricultural areas but higher than those from forests (see pp. 95 and 122). There is also a core national indicator for nitrogen (p. 46).

The technical note for this indicator is on page 267.



SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants Physical	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ● Phosphorus in Urban and Suburban Streams

### What Is This Indicator, and Why Is It Important?

This indicator reports the concentration of phosphorus in representative streams in urban areas. Specifically, the indicator reports the percentage of streams with average annual concentrations in one of four ranges, for streams draining watersheds that are primarily urban.

Phosphorus is an essential nutrient for all life forms and occurs naturally in soils and aquatic systems; phosphate is the most biologically active form of phosphorus. At high concentrations in freshwater systems, however, phosphorus can lead to algal blooms, which can decrease recreational and aesthetic values and help deplete oxygen needed by fish and other animals.

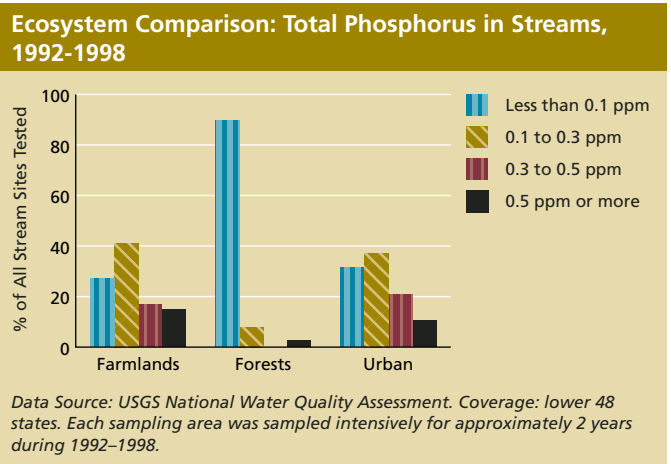
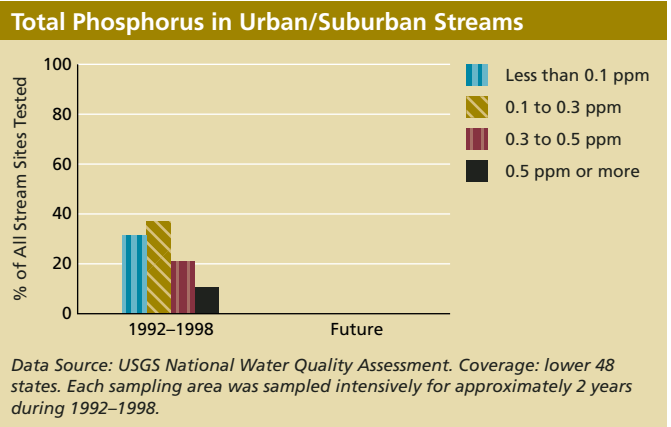
Sources of phosphorus in urban streams include effluent from sewage treatment plants, animal wastes, some detergents, and fertilizers used on lawns, gardens, golf courses, and agricultural fields.

**What Do the Data Show?** About two-thirds of stream sites in urban areas had concentrations of phosphorus that were at least 0.1 part per million (ppm), and about 10% of urban streams sites had concentrations of at least 0.5 ppm.

Streams in urban areas have similar average phosphorus concentrations to streams draining farmland watersheds.

**Discussion** The U.S. Environmental Protection Agency (EPA) has recommended 0.1 ppm as a goal for preventing excess algae growth in streams. In 2000, EPA took steps to facilitate development of regional criteria, but these regional criteria have not yet been adopted. There is no federal drinking water standard for phosphorus.

The technical note for this indicator is on page 267.

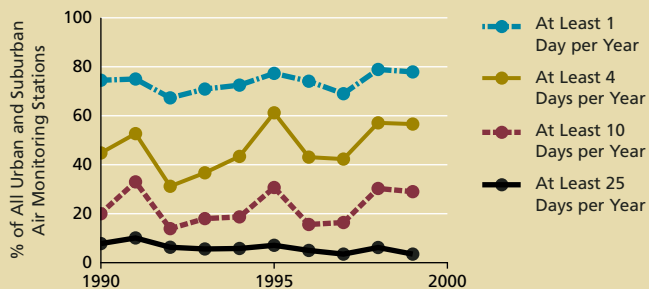




SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen <b>Contaminants</b> Physical	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ● Air Quality (High Ozone Levels)

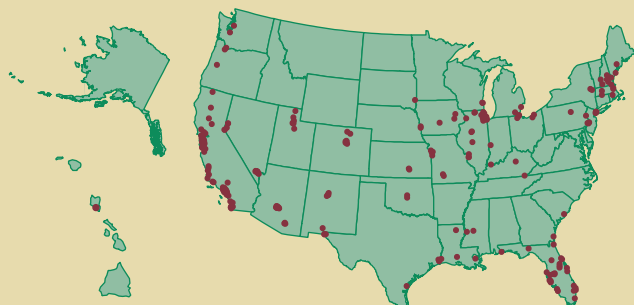
### Exceedances of 8-hour Ozone Threshold (0.08 ppm)



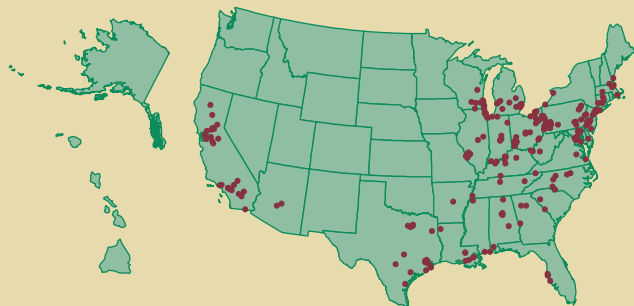
Data Source: U.S. Environmental Protection Agency. Coverage includes Alaska and Hawaii. Data from before 1990 exist, but they are not directly comparable. Only monitoring stations located in urban/suburban areas were included in the analysis.

### Air Monitoring Stations Exceeding 8-hour Ozone Threshold (0.08 ppm), 1999

#### 220 Stations with 1–3 Exceedances (45% of Stations)



#### 266 Stations With at Least 4 Exceedances (55% of Stations)



Data Source: U.S. Environmental Protection Agency. Coverage includes Alaska and Hawaii. Data from before 1990 exist, but they are not directly comparable. Only monitoring stations located in urban/suburban areas were included in the analysis.

### What Is This Indicator, and Why Is It Important?

This indicator reports the percentage of air pollution monitoring stations in urban and suburban areas with “high” ozone concentrations at least 1, 4, 10, and 25 days a year. Ground-level ozone is considered high when the 8-hour average concentration exceeds 0.08 parts per million (ppm). Violations of federal air quality standards are generally triggered by ozone concentrations exceeding this level for 4 or more days. For this reason, the maps show monitoring stations with less than 4 days and 4 or more days of high concentrations in 1999.

Ground-level ozone is one of the most pervasive air quality problems in the United States. Children and adults who are active outdoors, and people with respiratory diseases, are most likely to be harmed. Ozone can inflame the lungs, make people more susceptible to respiratory infection, and aggravate respiratory diseases such as asthma; repeated exposure may lead to permanent lung damage. High concentrations can harm trees, other plants, wildlife, and pets, and can damage painted surfaces, plastics, and rubber materials. In contrast, ozone in the upper atmosphere absorbs harmful ultraviolet radiation.

**What Do the Data Show?** In 1999, about 55% of monitoring stations in urban and suburban areas recorded high ozone levels on 4 or more days. The percentage of urban and suburban monitors with high ozone levels on 4 or more days per year fluctuated around 50% during the 1990s. The fluctuations are in large part due to year-to-year variability in weather conditions. The percentage of monitors recording high levels 25 or more times per year declined over the same period, to about 5% in 1999. Many of these monitors were in southern California, Houston, and Atlanta.

**Discussion** Ground-level ozone forms when pollutants from vehicles, paints and solvents, unburned fuel, and industrial sources “bake” in hot, sunny, stagnant

weather. Ground-level ozone is one of six common air pollutants considered harmful to human health and the environment (the others are lead, carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulate matter). While high concentrations of other pollutants do occur in some urban and suburban areas, ozone is responsible for more than 95% of all days with violations of any air quality standard.

The technical note for this indicator is on page 267.



SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen <b>Contaminants</b> Physical	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## Chemical Contamination

### What Is This Indicator, and Why Is It Important?

This indicator reports on contaminants found in urban and suburban streams and soils. The graph on the top reports the average number of contaminants detected throughout the year at urban and suburban stream sites, and the middle graph reports the percentage of stream sites with concentrations of chemical contaminants that exceeded standards or guidelines for the protection of human health or aquatic life. Compounds reported here include many pesticides, selected pesticide breakdown products, ammonia, and nitrate (because nitrate and ammonia occur naturally, they are not included in the graphs showing contaminant occurrence).

In sufficient quantities, contaminants such as pesticides can harm people as well as fish and other wildlife. The number of contaminants detected is important, but the presence of pesticides does not necessarily mean that the levels are high enough to cause problems. Comparison with standards and guidelines (benchmarks) provides a useful reference to help judge the significance of contamination.

However, appropriate benchmarks do not exist for many compounds: for example, there are no drinking water benchmarks for 33 of the 76 pesticides analyzed here and no aquatic life benchmarks for 48 of the 76. Current benchmarks do not account for mixtures of chemicals or seasonal pulses of high concentrations. In addition, potential effects on the reproductive, nervous, and immune systems, as well as on particularly sensitive individuals, are not yet well understood.

### Why Can't This Entire Indicator Be Reported At This Time?

Data are not currently available to report in a consistent manner on chemical contamination in urban and suburban soils.

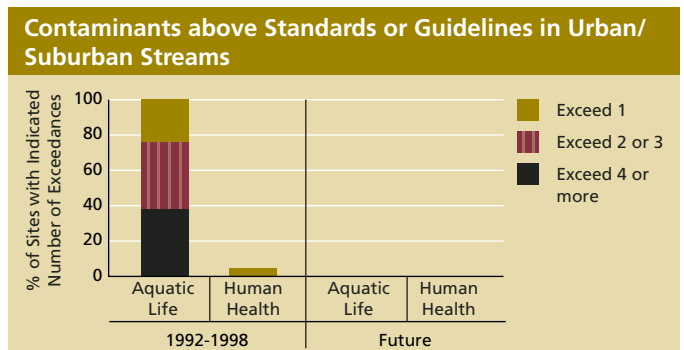
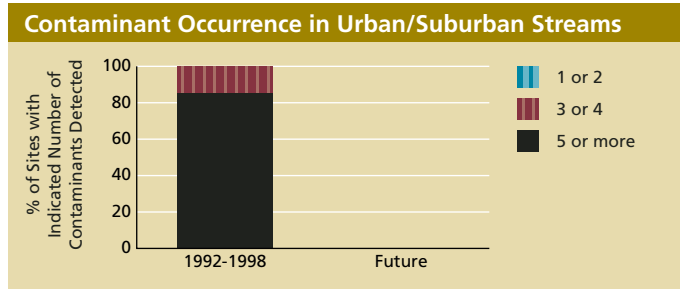
**What Do the Data Show?** About 85% of stream sites in urban and suburban areas had an average of at least five detectable contaminants throughout the year. All sites had at least one chemical that exceeded guidelines for protection of aquatic life, and about 5% of sites had a contaminant that exceeded human health standards or guidelines.

**Discussion** The data shown here do not represent assessments of the risks posed to people or ecosystems in any specific location, since they do not incorporate factors such as whether the water tested is actually used as a drinking water source or whether aquatic animals are biologically active at the time of year when the contaminants are found.

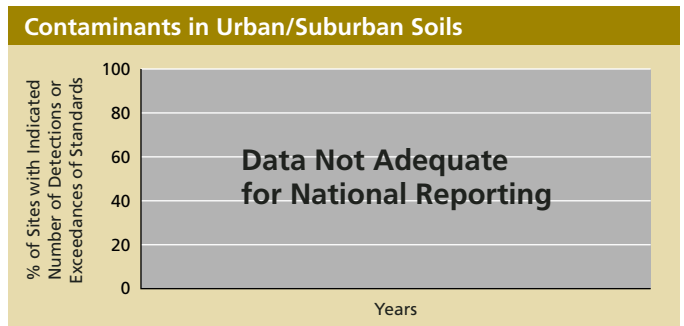
Guidelines for the protection of aquatic life are often numerically lower than similar benchmarks for human health. Aquatic animals spend much or all of their life in water and may be more sensitive to specific contaminants.

See also the national, coastal, and farmland contaminants indicators (pp. 48, 72, and 97).

The technical note for this indicator is on page 268.



Data Source: U.S. Geological Survey, National Water Quality Assessment Program (NAWQA). Coverage: lower 48 states. Note: Each sampling area was sampled intensively for approximately 2 years during 1992-1998.

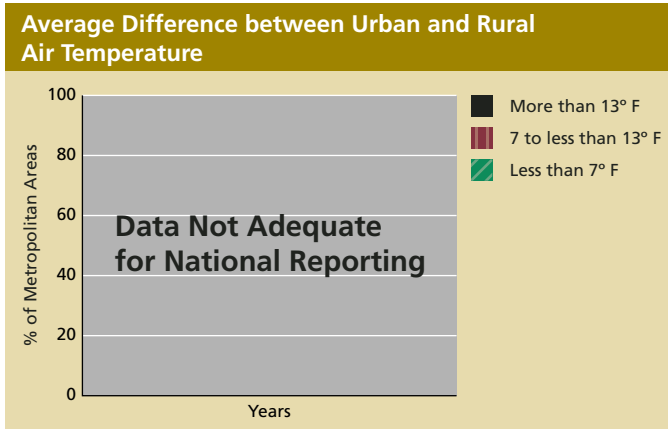




## Urban and Suburban Areas

SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants <b>Physical</b>	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

### ? Urban Heat Island



**What Is This Indicator, and Why Is It Important?** This indicator will describe the difference between urban and rural air temperatures for major U.S. metropolitan areas. Temperatures within urban areas will be compared to those in less-developed surrounding areas.

Extremely hot weather is responsible for greater loss of human life in the United States than hurricanes, lightning, tornadoes, floods, and earthquakes combined. Building density and type, amount of road surface, and energy use, as well as local topography and regional weather patterns, all work together to modify a city's climate. The urban heat island effect is often noticed

most at night when buildings and other constructed surfaces radiate the heat they have accumulated during the day. Beyond posing a threat to human health (through heat stroke, for example) and raising air conditioning costs, the heat island effect can cause physiological stress in other animals, change the mix of plants and animals that live in the area, and even lead to changes in the distribution of pathogens. Elevated temperatures also accelerate the formation of ground-level ozone (see Air Quality, p. 188) and other air pollutants that adversely affect human health.

**Why Can't This Indicator Be Reported at This Time?** There is no single metric that has been adopted by the scientific community as an indicator of the heat island effect. One possible presentation would report the percentage of all U.S. metropolitan areas where the average annual difference between urban and rural air temperatures is relatively small (less than 7°F), moderate (7° to less than 13°F), or large (more than 13°F). National Weather Service data could be used to determine current and historic heat island effects in many locations. However, there is no program in place either to retrieve and analyze historic information or to identify appropriate pairs of urban and rural sites necessary to make calculations of the heat island effect.

The technical note for this indicator is on page 268.



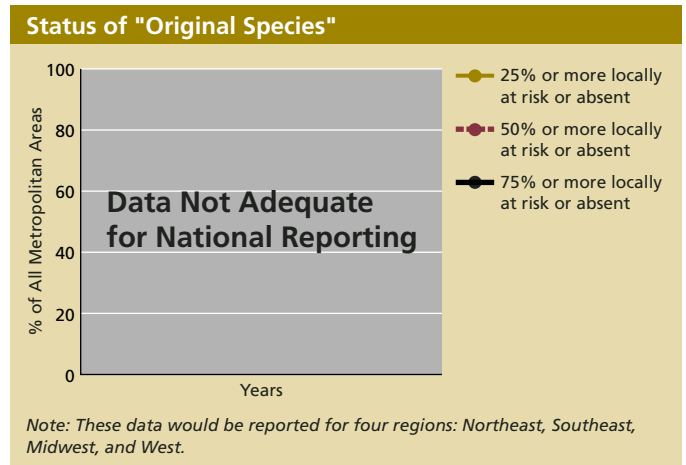
SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants Physical	<b>Plants and Animals</b> Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ⊖ Species Status

### What Is This Indicator, and Why Is It Important?

This indicator will report on the degree to which “original” plants and animals are either absent entirely or are at risk of being lost from metropolitan areas. Original species are those that, before European settlement, inhabited the lands now occupied by metropolitan areas. Specifically, the indicator will report on the fraction of metropolitan areas where 25% or more, 50% or more, and 75% or more of original species are at risk of being displaced or are absent.

Species differ in their ability to cope with urban/suburban development, and cities and suburbs differ in their capacity to accommodate those species common in the area before European settlement. How thoroughly an area is developed, and whether there are areas and corridors maintained for wildlife, has an influence on whether some species—those less tolerant of people and development—become reduced in population or displaced from the local area. Some of these species may have healthy populations outside cities and their suburbs, but in other cases the loss of habitat in urban and suburban areas can contribute to the overall decline of a species’ population. Efforts to improve or restore habitat within urban/suburban areas can increase the likelihood that original species will re-inhabit these areas.



### Why Can't This Indicator Be Reported at This Time?

The historical data necessary to establish lists of original species are incomplete, and current information on their status, especially within cities and their suburbs, is not systematically collected and reported. When available, the amount, quality, and format of such data are extremely variable.

**Discussion** Note that it is difficult to distinguish between at-risk and absent in this context, so both are included. In addition, presettlement is used as a benchmark simply as a way to track changes, not because the full suite of original species would necessarily be desirable in any given metropolitan area.

This indicator would not be calculated for all urban and suburban areas, as defined in this report (see Area of Urban and Suburban Lands, p. 181), as it is likely that information, expertise, and financial resources will be available only for larger metropolitan areas. Thus, it might be appropriate to base reporting for this indicator on data from a suite of cities (and their suburbs) whose population exceeds 100,000 or that cover at least 50 square miles, for example.

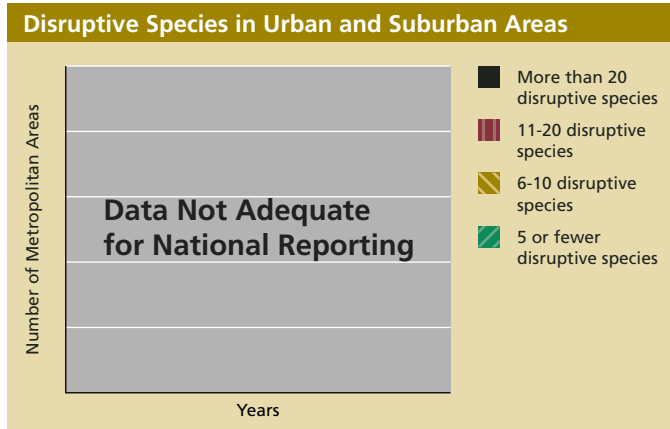
The technical note for this indicator is on page 269.



## Urban and Suburban Areas

SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants Physical	<b>Plants and Animals</b> Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

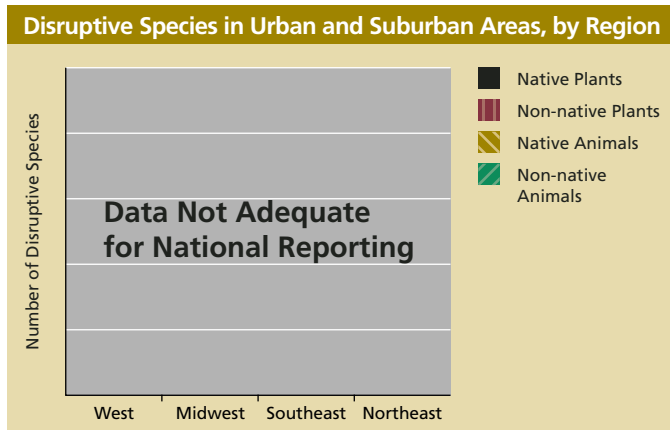
### ⊖ Disruptive Species



#### What Is This Indicator, and Why Is It Important?

This indicator would report the number and type of “disruptive” species found in metropolitan areas. Disruptive species are those that have negative effects on natural areas and native species or cause damage to people and property. Specifically, the indicator will report the number of larger metropolitan areas with 5 or fewer, from 6 to 10, from 11 to 20, and more than 20 disruptive plant and animal species. It would also report the number of disruptive native and non-native plant and animal species on a regional basis, for the most current year.

Some species of plants and animals are so abundant in urban and suburban areas that they disrupt other species and cause problems for people. In the Northeast, for example, white-tailed deer are major suburban pests. They damage native vegetation in natural areas, destroy crops and gardens, and are involved in countless automobile accidents. In and around Portland, Oregon, Scotch broom, native to the British Isles, is spreading rapidly, often growing in dense, nearly impenetrable clusters that make maintenance of roads, ditches, canals, and power and telephone lines difficult and costly. Minneapolis, among other cities in the Midwest, is taking action against disruptive woody plants like buckthorn, Tartarian honeysuckle, and mulberry, which are taking over the city’s woods and wetlands.



**Why Can’t This Indicator Be Reported at This Time?** Regional lists of disruptive species do not exist. Creating them requires definition of thresholds that distinguish truly disruptive species from those that cause fewer problems, as well as consistent policies for including species based on their potential to cause damage, as shown by experiences in other locations.

In addition, monitoring and reporting programs need to be put in place to track the occurrence of disruptive species. Many knowledgeable individuals and institutions could participate, but no entity currently has the mandate to coordinate such an activity.

**Discussion** Disruptive species may be native, or they may have been introduced from other regions or other countries. The altered landscape in urban and suburban areas encourages the growth of these species, which tolerate and even thrive around built-up areas. At the same time, populations of more sensitive species shrink, reducing competition and further encouraging the spread of disruptive species.

There is no technical note for this indicator.



SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants Physical	Plants and Animals <b>Communities</b> Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ⊖ Status of Animal Communities in Urban and Suburban Streams

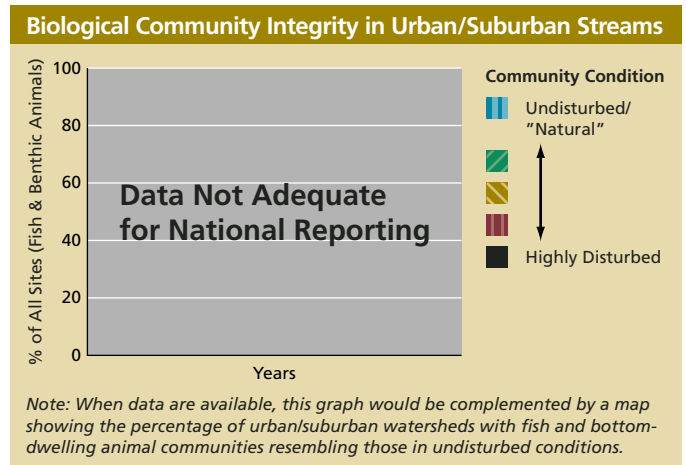
### What Is This Indicator, and Why Is It Important?

This indicator reports on “biological integrity” in streams in urban and suburban areas. Biological integrity is a measure of the degree to which the suite of fish and bottom-dwelling (or benthic) animals (including insects, worms, mollusks, and crustaceans) resembles what one might find in a relatively undisturbed stream in the same region. Tests assess the number of different species, number and condition of individuals, and food chain interactions. High scores indicate close resemblance to “reference” or undisturbed conditions, and low scores indicate significant deviation from them. (See also Status of Freshwater Animal Communities, p. 147.)

Undisturbed streams in a particular region have a relatively predictable set of fish and bottom-dwelling animals, in predictable proportions. The composition and condition of these biological communities may be altered, often as a result of development in the stream’s watershed. Sources of degradation include contaminated runoff from streets, driveways, lawns, golf courses, and the like, increased stream temperature caused by runoff that is warmed as it flows over paved surfaces, and channelizing or other modifications of the streambed. Some streams are so modified that, for example, both the number of species and the number of individuals are very low when compared to undisturbed areas, and many of those that remain are diseased or otherwise damaged. Ecosystems that are “healthy,” or show high integrity, are more likely to withstand natural and man-made stresses.

**Why Can’t This Indicator Be Reported at This Time?** The tests of biological integrity now in use must be tailored to ensure that each stream is compared with an appropriate reference from within the same region, but outside of the urban/suburban area. Only a handful of states regularly conduct quantitative tests of condition of fish or bottom-dwelling animal communities, and these are not specific to urban streams.

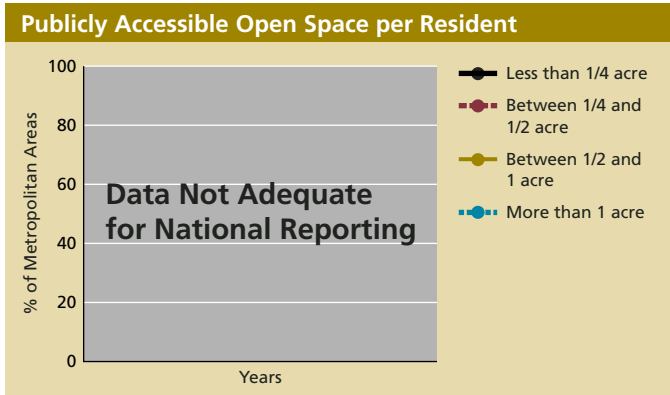
The technical note for this indicator is on page 269.





SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants Physical	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ⊖ Publicly Accessible Open Space per Resident



### What Is This Indicator, and Why Is It Important?

This indicator would report the amount of open space—land that is dominated by “natural” surfaces, like grass or woods, along with lakes, rivers, beaches, and wetlands—that is accessible to the general public in large metropolitan areas. Specifically, the indicator would report the percentage of metropolitan areas with different amounts of open space per resident.

Americans enjoy outdoor recreation, and urban and suburban residents place a high value on access to public spaces where they can picnic, play ball, swim, hike, fish, walk their dogs, enjoy nature, and engage in any of a

myriad of other outdoor activities. The amount of such open space per resident often determines how intensely such places will be used and how crowded they will be.

**Why Can't This Indicator Be Reported at This Time?** There are no consistent or comprehensive surveys of the amount of publicly accessible open space in cities and suburban areas. A combination of satellite remote sensing and local tax and land records would be required for reporting on this indicator.

**Discussion** This indicator focuses on public areas that are natural or relatively undeveloped. In practice, this means that areas dominated by grass, woods, dirt, or other unpaved surfaces would be counted, while predominately paved areas would not (paved walkways in a park that is primarily grass would not “disqualify” the area). In addition, areas counted in this indicator are those that are accessible to the general public, even if fees (such as for a county-run golf course) are charged. Thus, a public golf course and even some cemeteries would qualify, but a farm or a country club would not. Note that a change in population without a change in open space would change the value of this indicator. Area of Urban and Suburban Lands (p. 181) provides a context for this indicator, because it reports the overall percentage of natural lands in the urban/suburban landscape; however, it does not distinguish between publicly accessible and inaccessible lands.

The technical note for this indicator is on page 269.



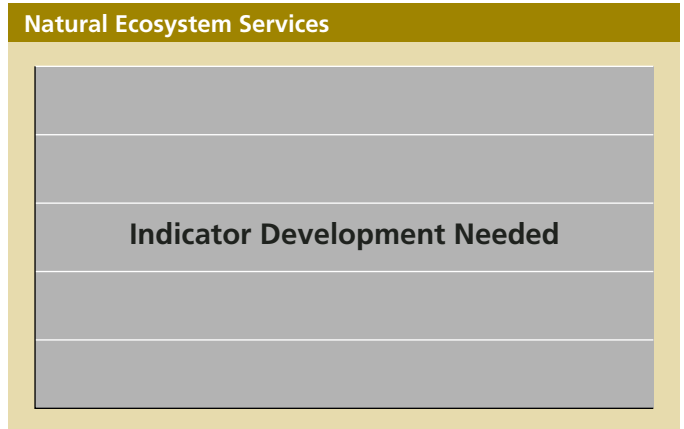
SYSTEM DIMENSIONS	CHEMICAL AND PHYSICAL	BIOLOGICAL COMPONENTS	HUMAN USES
Extent Pattern	Nutrients, Carbon, Oxygen Contaminants Physical	Plants and Animals Communities Ecological Productivity	Food, Fiber, and Water Recreation and Other Services

## ❓ Natural Ecosystem Services

### What Is This Indicator, and Why Is It Important?

Urban and suburban areas are defined by what people have built, but the remaining “natural” components—trees, meadows, streams, wetlands, and the like—provide valuable services to the residents of these developed areas. Ecosystem services are the benefits, both tangible and intangible, that these natural elements provide. For example, forested areas reduce stormwater runoff, when compared to paved areas, and trees cool streets and buildings, reducing energy consumption; trees also reduce urban noise levels. Natural areas, including forests, grasslands and shrublands, beaches, lakes, streams, and wetlands, also provide recreational opportunities, increase property values and community amenities, and are aesthetically pleasing.

In urban and suburban areas, the loss of ecosystem services is often not recognized until a functioning ecosystem has already been altered, and millions or even billions of dollars are needed for technological fixes. Suburban development in the Catskill Mountains, the primary source of water for New York City, has jeopardized water quality, potentially requiring a filtration system costing billions of dollars to construct and millions of dollars a year to operate, in order to provide the same water quality as was provided before development. In another example, the nonprofit organization American Forests found that trees in the Denver/Front Range area provide the equivalent of a \$44 million stormwater management system.



**Why Can't This Indicator Be Reported at This Time?** Scientists are uncertain about how to measure ecosystem services in urban, and other, ecosystems. They may rely, for example, on tree canopy as a surrogate measure because of its influences on air quality, water flow, property values, microclimates, and aesthetics. Scientists are working to quantify the relationship, which is likely to be stronger in some areas than in others, between the amount of tree canopy and the levels of services provided. Other components of the urban/suburban ecosystem, like wetlands, streams, and grasslands, also provide important services, and these should be incorporated as well.

**Discussion** Considerable scientific effort needs to be invested in understanding the relationship between various ecosystem components and the kinds of services they provide. Recently, the National Science Foundation's Long Term Ecological Research Network established research sites in Baltimore, Maryland, and Phoenix, Arizona, to study the ecology of cities (see <http://lternet.edu/>). These sites seek to understand the nature and functioning of urban and suburban ecosystems, and how people influence and are influenced by them. Through such detailed studies and the accompanying long-term observation of changes in urban and suburban areas, it will be possible to quantify ecosystem services and understand how urbanization alters these services.

There is no technical note for this indicator.

