5.5 What Is the Ecological Condition of Urban and Suburban Areas?

Urban and suburban ecosystems are areas where the majority of the land is devoted to or dominated by buildings, houses, roads, concrete, grassy lawns, or other elements of human use and construction (The Heinz Center, 2002). Urban ecosystems are highly built-up and paved over, resulting in more rapid changes in temperature, runoff, and other variables than in more natural ecosystems. Plant and animal life is heavily influenced by species introduced in horticulture and as pets, and native plant species might be more or less completely removed from large areas and replaced by lawns, gardens, and ornamentals (WRI, 2000). These areas generally show high levels of many air and water pollutants because of the concentration of pollutant sources in small areas. Nonetheless, substantial biodiversity

Exhibit 5-22: Urban and suburban indicators

Essential Ecological Attribute	Indicators	Category 1	Category 2	Source
Landscape Condition		1	2	
Extent of Ecological System/Habitat Types	Extent of urban and suburban lands	■		USDA
Landscape Composition	Patches of forest, grassland, shrubland, and wetland in urban/suburban areas		■	DOI
Landscape Structure/Pattern				
Biotic Condition				
Ecosystems and Communities				
Species and Populations				
Organism Condition				
Ecological Processes				
Energy Flow				
Material Flow				
Chemical and Physical Characteristics				
Nutrient Concentrations	Nitrate in farmland, forested and urban streams and ground water		■	DOI
	Phosphorus in farmland, forested and urban streams		■	DOI
Other Chemical Parameters				
Trace Organics and Inorganics	Chemical contamination in urban streams and ground water		■	DOI
	Ambient concentrations of ozone, 8-hour and 1-hour	■		EPA
Physical Parameters				
Hydrology and Geomorphology				
Surface and Ground Water Flows				
Dynamic Structural Conditions				
Sediment and Material Transport				
Natural Disturbance Regimes				
Frequency				
Extent				
Duration				

can remain in these systems; for example, a 1993 survey identified 115 bird species in Washington, DC (Hadidian, et al., 1997).

There is substantial interest in understanding urban and suburban ecosystems, as evidenced by two urban National Science Foundation long-term ecological research sites (Phoenix and Baltimore), a professional journal, *Urban Ecosystems* and a number of recent writings on the subject (Pickett, et al., 2001; Kinzig and Grove, 2001; Grimm, et al., 2002). Much of urban ecosystems research is aimed not at preserving natural ecosystems, but at "smart growth" and understanding how to enhance ecosystem services in a highly built environment. Despite the growing amount of research, the entire science of urban ecosystem ecology is not sufficiently developed to have a substantial number of ecological indicators. In addition, there may be a lack of understanding regarding what to expect when applying indicators typically used in less built-up land cover classes to urban and suburban ecosystems. The Heinz report lists eight indicators for urban and suburban ecosystems, only two of which have adequate data for national reporting.

Indicators for urban and suburban ecosystems used in this report are listed in Exhibit 5-22, grouped according to essential ecological attributes. Extent and chemical and physical condition data are the most widely available. There were no indicators for biotic condition, ecological processes, hydrology and geomorphology, or natural disturbance regimes for urban and suburban ecosystems suitable for national or even regional reporting (The Heinz Center, 2002).

This section summarizes data related to urban and suburban ecosystems for five indicators, most of them relating to pollutant concentrations, that appear in earlier chapters. The section then introduces one indicator that appears for the first time in this report—*Patches of Forest, Grassland, Shrubland, and Wetland in Urban/Suburban Areas*—which relates to the landscape essential ecological attribute.

The following indicators presented in previous chapters relate to the ecological condition of urban and suburban areas:

- The indicator *Extent of Urban and Suburban Lands* (Chapter 3, Better Protected Land) was assessed using the National Land Cover Database and estimating the proportion of the area in 1,000 foot pixels that fell into one of four developed land cover types: low-intensity residential; high-intensity residential; commercial-industrial-transportation; or urban and recreational grasses (The Heinz Center, 2002). In 1992, urban and suburban areas occupied about 32 million acres in the conterminous U.S. or about 1.7 percent of the total land area (The Heinz Center, 2002). As with the estimate of the extent of farmlands, urban and suburban areas are defined differently by different organizations, sometimes using different data sources, thus affecting the area estimates. For example, the Extent of Developed Lands indicator in Chapter 3, Better Protected Land is based on USDA National Resources Inventory delineation of developed lands, which is about 98 million acres in the conterminous U.S., or about 4.3 percent of the total land area of the U.S., not including Alaska (see Chapter 3, Better Protected Land).
- The indicator A*mbient Concentrations of Ozone, 8-hour and 1-hour* (Chapter 1, Cleaner Air) revealed that in 1999, about 55 percent of the urban and suburban monitoring stations had high ozone concentrations on 4 or more days, and that the percentage fluctuated between 35 percent and 60 percent during the 1990s (The Heinz Center, 2002). The number of sites with 10 days or more of high ozone fluctuated between 20 and 30 percent of the sites, with no apparent trend, but the number of sites with high ozone on 25 days or more decreased from about 10 percent to around 5 percent over the decade. Fluctuations are caused in part by changes in the weather. As noted in the section on forests, biomonitoring plots frequently reveal at least some ozone damage to tree leaves.
- The indicator *Nitrate in Farmland, Forested, and Urban Streams and Ground Water* (Chapter 2, Purer Water), shows that 40 percent of 21 streams in which the predominant land use was urban and suburban had nitrate concentrations above 1.0 ppm; 25 percent had concentrations below 0.5 ppm; and 3 percent had concentrations below 0.1 ppm (The Heinz Center, 2002). Concentrations of nitrate in these urban streams were generally lower than those of agricultural watersheds, but higher than those in forested watersheds.
- The indicator *Phosphorus in Farmland, Forested, and Urban Streams (*Chapter 2, Purer Water) showed that two-thirds of 21 urban streams sampled had phosphorus concentrations of at least 0.1 ppm, a level usually associated with excess algal growth (The Heinz Center, 2002). About 10 percent of the urban streams had concentrations of at least 0.5 ppm.
- According to the indicator *Chemical Contamination in Streams and Ground Water* (Chapter 2, Purer Water), 85 percent of 21 urban streams sampled had an average of about five detectable contaminants throughout the year (The Heinz Center, 2002). All of the streams had at least one chemical that exceeded guidelines for the protection of aquatic life. For many urban and suburban streams, the nutrient and contaminant signature is similar to the signatures from agroecosystems (The Heinz Center, 2002; Wickham, et al., 2002).

The following indicator, *Patches of Forest, Grassland, Shrubland, and Wetland in Urban/Suburban Areas,* provides data on landscape condition in urban and suburban areas.

Indicator | Patches of forest, grassland, shrubland, and wetland in urban/suburban areas - Category 2

Patches of forest, grassland, shrubland, and wetland in urban/suburban areas provide habitat for birds, amphibians, and small mammals. They also increase water infiltration and reduce temperature by evapotranspiration. Patches of urban and suburban vegetation generally reduce particulate matter, and they can increase or decrease ozone concentrations, relative to built surfaces (Nowak, et al., 2000). According to The Heinz Center (2002), the size of patches of undeveloped land in urban and suburban areas is important, with smaller patches generally considered to provide poorer quality habitat. Recent studies have indicated a significant loss of forest patch coverage in Atlanta and Baltimore in the last several decades (American Forests, 2001, 2002).

What the Data Show

Around half of the undeveloped land in urban and suburban areas occurs in patches smaller than 10 acres (Exhibit 5-23). Urban and suburban areas in the Northeast have the largest percentage of large (1,000 to 10,000 acres) patches of undeveloped land. Patches of undeveloped land larger than 10,000 acres occur only in urban and suburban areas of the West.

Indicator Gaps and Limitations

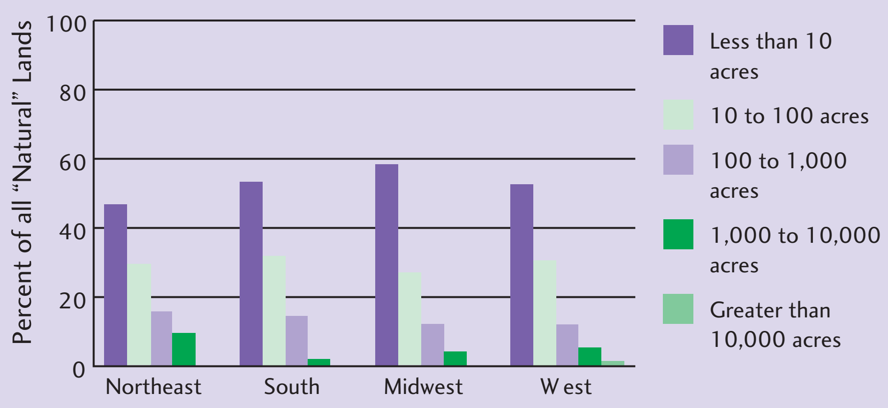
Several limitations are associated with this indicator:

- Natural patches may extend beyond the boundary of the "urban and suburban area" land use class, which would cause the size of the patches to be underestimated.
- Very small patches are difficult to distinguish if they are mixed with developed classes, which also leads to underestimates.
- Remote sensing cannot distinguish between land that has always been "non-urban" and patches, such as landfills, that have reverted to grasslands or forest.
- Patch size is not the only factor that contributes to habitat quality (The Heinz Center, 2002).

Data Source

The data source for this indicator was the National Land Cover Database, Multi-Resolution Land Characterization Consortium (1990s). (See Appendix B, page B-43, for more information.)

Exhibit 5-23: Patches of forest, grassland, shrubland, and wetland in urban and suburban areas, 1992



Coverage: lower 48 states

Source: The Heinz Center. *The State of the Nation's Ecosystems.* 2002. Data from Multi-Resolution Land Characteristics Consortium, and the USGS Earth Resources Observations Systems Data Center.

Summary: The Ecological Condition of Urban and Suburban Ecosystems

Urban and suburban systems have been the subject of increasing ecological interest, but their overall condition, nationally or even regionally, is virtually unknown.

Landscape condition

Within the technical limitations of using remote sensing data to define urban and suburban ecosystems and the landscape patches they contain, The Heinz Center (2002) has established a baseline against which to judge current trends in urbanization. In 1992, urban and suburban areas occupied about 32 million acres in the conterminous U.S. or about 1.7 percent of the total land area, but different organizations, sometimes using different data sources, produce different estimates. For example, USDA National Resources Inventory delineation of developed lands, estimates there to be about 98 million acres in the conterminous U.S., or about 4.3 percent of the total land area of the U.S., not including Alaska (see Chapter 3, Better Protected Land). However, there is currently no firm plan in place to collect the remote sensing data in the future to allow trends to be calculated. Although the land use indicators identified provide some useful information on extent, they do not address the actual condition of those lands. Given the concentration of the human population in developed areas of the country, a better understanding of the interaction among humans and their developed environment could help improve human health and the effects of developed lands on ecological condition.

Chemical and physical characteristics

Chemical data from the NAWQA program used to develop the stream quality indicator in this report and the Heinz report (2002) include only 21 urban streams across the entire U.S. Nitrate and phosphorus concentrations in these streams were intermediate between farmlands and forest streams, but all of them had at least one chemical that exceeded guidelines for the protection of aquatic life. Given the numerous factors that can affect these systems, 21 streams are not likely to be an adequate baseline against which to track the progress of environmental protection activities, including stormwater management, controls on non-point source pollution from lawns, golf courses, and septic systems, with any statistical certainty. An indicator of the extent of impervious surfaces might be useful for inferring non-point source pollution impacts.

There were no Category 1 or 2 indicators available for this for *biotic condition, ecological processes,* or *natural disturbance regimes.* The Heinz Center (2002) identified several indicators that could be promising but for which there are not even regional data:

- An indicator that would report on the percentage of urban and suburban areas in which <25 percent, 25 to 50 percent, 50 to 75 percent, and >75 percent of the original species had been lost or displaced.
- An indicator that would report on the number of nuisance species in urban and suburban areas (e.g., white-tailed deer, kudzu).
- Fish Index of Biotic Integrity (IBI) and Macroinvertebrate Biotic Integrity Index (MBII) indicators in urban/suburban streams.
- An indicator that would report on the coverage of stream bank vegetation.

The lack of national biotic indicators for urban fresh water systems makes it particularly difficult to measure national progress in maintaining balanced communities in urban streams.

A particular problem in urban and suburban systems is establishing appropriate reference conditions for biological structure and ecosystem function measures (The Heinz Center, 2002). For example, expecting fish and invertebrate communities in urban streams to be typical of relatively undisturbed forest or grassland ecosystems would be unrealistic. Data are insufficient on both the current status of species and the original species present to calculate the number of native species lost. As another example, an indicator tracking national trends in urban stream buffers would be particularly helpful to states tracking the effectiveness of watershed management programs. However, a decision would be needed on a threshold for buffer strips of adequate width to protect stream channels, and further development of satellite measurements would be needed before such an indicator could be used for national reporting.

A potentially useful hydrology/geomorphology indicator would be the percentage of impervious area (The Heinz Center 2002). Impervious areas generally increase runoff from rain events, leading to modified stream channels, increased stream temperatures, decreased infiltration, and pollutants carried into ecosystems (e.g., Booth and Jackson, 1997). According to The Heinz Center, however, although some local governments collect data on impervious surfaces, it is difficult to measure (Arnold and Gibbons, 1996), and there are insufficient data on this indicator for national reporting. Tracking impervious surface changes may be important for measuring progress in reducing the impact of stormwater runoff on the quality of receiving streams.

Another potentially useful indicator is the urban heat island (The Heinz Center 2002). Urban heat islands raise the ambient temperature surrounding both terrestrial and aquatic ecosystems. Because chemical and biological reaction rates are temperature dependent, increased heating and temperatures can increase the stress on all biological species, both directly and indirectly. Dissolved oxygen saturation is lower in warmer water, so aquatic organisms, with higher metabolic rates and the need for greater oxygen supplies, have less oxygen available in the water because of lower oxygen saturation in warm water. The heat island effect can also have important impacts on air quality in urban and downwind areas (Nowak, et al., 2000). Again, the data may be available to calculate this indicator, but it has not been developed nationally.