URBAN ECOSYSTEMS

Urban areas are some of the most significant sectors on the planet in terms of human well-being, productivity, and ecological impact. Cities are centers of commerce, industrial output, education, culture, and technological innovation. As nexuses of the world's market economies and home to more than 2.7 billion people (World Bank 2000:152), cities are also centers of natural resource consumption and generators of enormous amounts of wastes, with environmental ramifications both locally and in distant ecosystems.

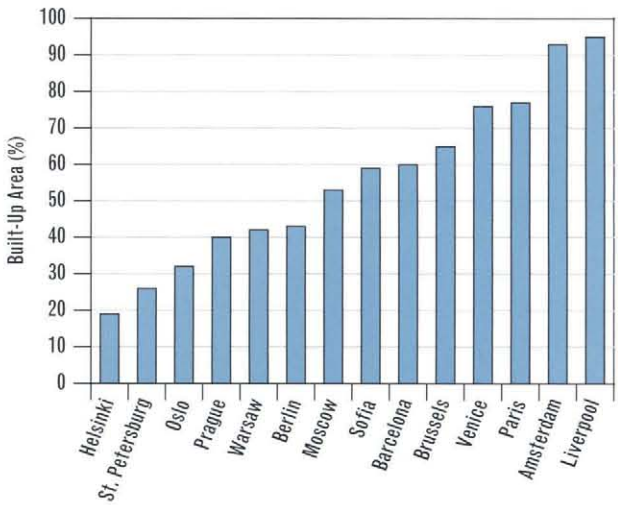
Urbanization's tremendous influence on humans and the environment will surely grow, as it is projected that global urban populations will nearly double by 2030 to 5.1 billion (UN Population Division 1996). But do urban areas–or portions of them–function as ecosystems? What defines an urban ecosystem?

Urban Ecosystems: Extent and Modifications

The concept of urban areas as ecosystems is new and controversial. There is no agreed-upon definition of an urban ecosystem, but the simplest and most useful one may be "a biological community where humans represent the dominant or keystone species and the built environment is the dominant element controlling the physical structure of the ecosystem." The physical extent of urban ecosystems is determined by the densities of both population and infrastructure. Administrative boundaries of cities generally are not reliable indicators of urban ecosystem boundaries for a number of reasons. For example, the U.S. Census Bureau defines urban areas as "areas where population density is at least 1,000 people/mi^2 (621 people/km^2)" (US Census Bureau 1995) but doesn't define a minimum infrastructure density. Another complicating factor is that urban areas are not sharply delineated but blend into suburbs and then rural areas. The PAGE estimate, however, is that urban ecosystems cover about 4 percent of the world's surface (see Box 1.10 Domesticating the World: Conversion of Natural Ecosystems, pp. 24-25).

Urban ecosystems, unlike natural ecosystems, are highly modified, with buildings, streets, roads, parking lots, and other artificial constructions forming a largely impenetrable

Built-Up Area of Selected European Cities



Source: Eurostat et al. 1995:202. 205.

Urban Tree Cover in Selected Cities

Tree cover in cities varies because of differences both in management and in the natural environment, particularly precipitation.

City	Tree Cover (%)
Baton Rouge, Louisiana (USA)	55
Waterbury, Connecticut (USA)	44
Portland, Oregon (USA)	42
Dallas, Texas (USA)	28
Denver, Colorado (USA)	26
Zurich, Switzerland	24
Windsor, Canada	20
Colima, Mexico	15–20
Hong Kong	16
Los Angeles, California (USA)	15
Chicago, Illinois (USA)	11
Ciudad Juarez, Mexico	4

Source: Nowak et al. 1996.

covering of the soil. Cities do contain natural and seminatural ecosystems–lawns and parks, forests, cultivated land, wetlands, lakes, streams–but the vegetation in those areas may be altered or highly managed, too.

Urbanization can change the structure and composition of vegetation of a region, whereby indigenous plants are replaced by nonnative species. For example, in the former West Berlin, approximately 40 percent of more than 1,400 plant species currently identified in the city are nonnative, and nearly 60 percent of native species are endangered (Kowarik 1990:47). In wooded areas, the ground leaf layer may be removed and replaced with shade-tolerant grass, disrupting the natural processes that create healthy soils and reducing an area's suitability as habitat for wildlife (Adams 1994:34).

Environmental stresses also modify the natural elements of urban ecosystems. Urban trees are subject to high levels of air pollutants, road salts and runoff, physical barriers to root growth, disease, poor soil quality, and reduced sunlight. Animal and bird populations are inhibited by the loss of habitat and food sources, toxic substances, and vehicles, among other intrusions.

Open space and tree cover vary widely in cities, depending on the natural environment and land use. In the United States, one analysis of more than 50 cities found that urban tree cover ranged from 0.4 percent in Lancaster, California, to 55 percent in Baton Rouge, Louisiana (Nowak et al. 1996:51).

Goods and Services Provided by Urban Ecosystems

The human elements of the city–its man-made infrastructure and economy–provide goods and services of enormous value, including human habitat, transportation networks, and a wide variety of income opportunities. But green spaces, which often form the vital heart of urban ecosystems, also contribute a wide range of goods and services. Just a few of them are focused on here.

AIR QUALITY ENHANCEMENT AND TEMPERATURE REGULATION

Temperatures in heavily urbanized areas may be 0.6–1.3°C warmer than in rural areas (Goudie 2000:350). This "heat island" effect is the result of large areas of heat-absorbing surfaces, like asphalt, combined with a city's building density and high energy use. Higher temperatures, in turn, make cities incubators for smog. Air pollution levels in megacities like Beijing, Delhi, Jakarta, and Mexico City sometimes exceed WHO health standards by a factor of three or more (WRI et al. 1998:63).

Green space within cities significantly lowers overall temperatures and thus reduces energy consumption and air pollution (Lyle and Quinn 1991:106, citing Bryson and Ross 1972:106). A single large tree can transpire as much as 450 liters of water per day, consuming 1,000 megajoules (239,000 kcal) of heat energy to drive the evaporation process (Bolund and Hunhammer 1999:296). Urban lakes and streams also help moderate seasonal temperature variations. Urban trees and forests remove nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone, and particulate matter. Trees in Chicago, for example, have been estimated to remove 5,575 tons of air pollutants per year, providing air cleansing worth more than US$9 million (Nowak 1994:71, 76). Urban forests in the Baltimore/Washington region remove 17,000 tons of pollutants per year, providing a service valued at $88 million (American Forests 1999:5). Even peripheral forests help urban air quality. Wind currents over the central city of Stuttgart, Germany draw cooler air from surrounding forest belts, cooling the downtown areas–one reason why Stuttgart has discouraged urban sprawl (Miller 1997:65, citing Miller 1983).

BIODIVERSITY AND WILDLIFE HABITAT

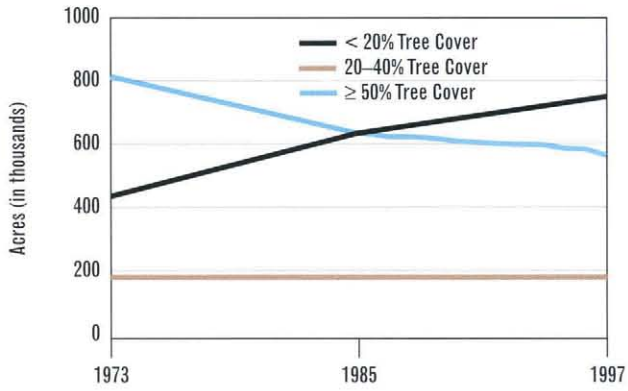
Cities support a relatively wide variety of plants and animals–both the native species that have specifically adapted to the urban landscape and its extreme ecological conditions and the numerous nonnative species humans have introduced.

Many of the animals, birds and fish that inhabit urban areas are valuable for the excitement and pleasure they bring to many urbanites, though some species are perceived as nuisances or dangerous. Almost a third of urban residents surveyed in the United States–more than 40 million people–report that they participate in wildlife watching activities

Changes in Tree Cover in the Baltimore-Washington Corridor, 1973–97

Overall tree cover has declined steadily in the rapidly growing Baltimore-Washington, D.C., urban corridor in the eastern United States. Urban and suburban expansion, as well as diminishing budgets for urban tree care, have shrunk tree cover from 51 percent of the land area in 1973 to 37 percent in 1997. Land with heavy tree cover (>50 percent wooded) declined by one-third, while land with little or no tree cover increased by nearly 60 percent.

Tree Cover Trends, 1973–97



Source: American Forests 1999.

within 1 mile of their homes (U.S. Department of the Interior 1997:94).

Some urban wildlife also is valuable from the perspective of conservation and biodiversity. Urban parks and other green spaces are critical to migratory species and provide wildlife corridors, even though these corridors are often too fragmented to afford animals sufficient area to maintain diverse populations. Nevertheless, in many North American urban areas, deer and small herbivores such as squirrels are prevalent. Muskrats and beavers may be widespread in urban water areas, and some smaller predators like bats, opossum, raccoon, coyote, fox, mink, and weasels adapt well to the habitat changes wrought by development (Adams 1994:57–65). Rats, as scavengers, have adapted particularly well to crowded human living conditions.

Many urban streams are so polluted, littered, or channelized, or their riparian zone so substantially reduced and cleared of vegetation, that only the most pollution-tolerant species survive. Yet urban rivers also offer some of the greatest potential for restoration and the return of aquatic diversity. For example, in 1957 London's Thames was virtually devoid of fish in one stretch, but by 1975 efforts to improve the biological conditions were rewarded with the return of 86 different species of marine and freshwater fish (Douglas 1983:137).

Bird diversity in urban areas may provide a good indicator of urban environmental quality, since birds require differentiated habitat and are influenced by air and aquatic pollution through the food chain. For example, a 1993 survey of Washington, D.C., bird species richness identified 115 species–an

In Cuba in 1999, urban agriculture produced 800,000 tons of fresh organic produce and employed 165,000 people. Urban agriculture produced 65 percent of the nation's rice, 43 percent of the fruits and vegetables, and 12 percent of the roots and tubers.

estimate that agreed closely with totals from surveys decades earlier, and was almost as high as the number found in larger, surrounding counties. This suggests that Washington, D.C.–perhaps because parks and low to moderate density residential areas cover 70 percent of the metropolitan area–is providing diverse and good-quality habitat for birds. Unfortunately, such citywide studies are rare (U.S. National Biological Survey 2000).

STORM-WATER CONTROL

Urban forests, wetlands, and streamside vegetation buffer storm-water runoff, control pollution, help recharge natural groundwater reservoirs, and minimize flooding in urban areas. In contrast, buildings and roads cover much urban land with impervious surfaces and eliminate vegetation that provides natural water storage capacity.

Some studies have attempted to put a monetary value on the benefit of urban forests to storm-water control. Forests in the Baltimore/Washington area save the region more than $1 billion–money that would otherwise have to be spent on storm-water retention ponds and other systems to intercept runoff (American Forests 1999:2). Unfortunately, in most cities worldwide, urban trees are a resource at risk. Since the 1970s, three major U.S. metropolitan areas–Seattle, Baltimore/Washington, and Atlanta–have lost more than a third of their heavy tree cover (Smith 1999:35).

FOOD AND FIBER PRODUCTION

Many urban areas contribute substantially to their food supply. Urban agriculture includes aquaculture, orchards, and livestock and crops raised in backyards and vacant lots, on rooftops and roadsides, and on small suburban farms (UNCHS 1996:410). Urban and periurban agriculture is estimated to involve 800 million urban residents worldwide (FAO 1999). In Kenya and Tanzania, 2 of 3 urban families are engaged in farming; in Taiwan, more than half of all urban families are members of farming associations; in Bangkok, Madrid, and San Jose, California, up to 60 percent of the metropolitan area is cultivated (Smit and Nasr 1992:142; Chaplowe 1998:47). In Ghana's capital, Accra, urban agriculture provides the city with 90 percent of its fresh vegetables (The MegaCities Project 1994). Urban agriculture also provides subsistence opportunities and income enhancement for the poor and offers a way to recycle the high volumes of wastewater and organic solid wastes that cities produce.

RECREATIONAL OPPORTUNITIES AND AESTHETIC HAVENS

Trees provide visual relief, privacy, shade, and wind breaks. Trees and shrubs can also reduce cities' typically high noise levels; a 30-m belt of tall dense trees combined with soft ground surfaces can reduce noise by 50 percent (Nowak and Dwyer 1996:471). Parks provide urban dwellers with easy access to recreational opportunities and places to relax–an enormously valuable service where open space and escape from asphalt are often at a premium. Some urban parks, lakes, and rivers are also tourist attractions and enhance values of downtown areas. Furthermore, urban water bodies provide places for sportfishing, kayaking, sailing, and canoeing.

Managing Urban Areas as Ecosystems

One of the primary challenges to managing urban areas as ecosystems is the lack of information. Because the science of urban ecology is in its infancy, the knowledge base for urban areas as ecosystems is less comprehensive than for other ecosystems. In particular, there is a dearth of data concerning the "green" elements of cities. Air and water quality, sewerage connections, water withdrawals and solid waste per capita, and trends in the extent of urban forests and wildlife diversity are critical indicators of the condition and capacity of the more natural areas in urban spaces to provide environmental goods and services.

Another problem is lack of planning and budgeting for the care of green spaces; most budgets are geared toward removing dead trees. Many cities lack systematic tree-care programs, and little attention is paid to effects of soil conditions, restrictions to root growth, droughts caused of the channeling off of rain, the heat island effect, and the lack of undergrowth (Sampson 1994:165).

Managing urban consumption and its impact on neighboring ecosystems is perhaps the biggest challenge. Urban areas consume massive amounts of environmental goods and services–imported from ecosystems beyond their borders–and export wastes. It is estimated that a city with a population of 1 million in Europe requires, every day, an average of 11,500 tons of fossil fuels, 320,000 tons of water, and 2,000 tons of food, much of which is produced outside the city. The same city produces 300,000 tons of wastewater, 25,000 tons of CO_2, and 1,600 tons of solid waste (Stanners and Bordeau 1995:263). The total area required to sustain a city is called its "ecological footprint" (Rees 1992). In a study of the 29 largest cities in the Baltic Sea region, it was estimated that cities claim ecosystem support areas 500–1,000 times larger than the area of the cities (Folke et al. 1997:167). Any attempt to improve the sustainability of urban ecosystems must identify ways for cities to exist in greater equalibrium with surrounding ecosystems.

The good news is that urban areas present tremendous opportunities for greater efficiencies in energy and water use, housing, and waste management. Strategies that encourage better planning, mixed-use development, urban road pricing, and integrated public transportation, among other efforts, can dramatically lessen the environmental impacts of billions of people. The fact that land use changes rapidly in urban areas is a management and planning challenge, but also an opportunity as well. For example, the million or more brownfields (urban land parcels that once supported industry or commerce but lie abandoned or contaminated) that scar cities worldwide offer the chance to create new green spaces or lessen congestion and development pressure on remaining green areas (Mountford 1999). If well-managed, urban green spaces can add to the already proven health and education benefits of urban ecosystems.

The Bottom Line for Urban Ecosystems. Urban ecosystems are dominated by human activities and the built environment, but they contain vital green spaces that confer many important services. These range from removing air pollution and absorbing runoff to producing food through urban agriculture. Urban forests, parks, and yards also soften the urban experience and provide invaluable recreation and relaxation. The science of urban ecosystems is new and there is no comprehensive data showing urban ecosystem trends on a global basis. However, more localized data show that loss of urban tree cover, and the consequent decline of urban green spaces, is a widespread problem. The rapid growth in urban populations worldwide adds to the mounting stress on urban ecosystems. Continued decline in the green elements of urban ecosystems will erode the other values—economic, educational, and cultural. Urban population increases heighten the need to incorporate the care of city green spaces as a key element in urban planning.