25: Urban Ecology

Learning Objectives

After completing this chapter, you will be able to:

1. Explain the factors that allow cities to exist and support their human population.
2. Describe recent trends of rapid urbanization.
3. Describe the structural and functional characteristics of the urban ecosystem.
4. Define the concept of an ecological footprint.
5. Explain the essential elements of urban planning and how it has affected land-use in Canadian cities.
6. List the major kinds of urban pollution and describe their causes and recent trends in Canadian cities.
7. Describe the methods of waste management.
8. Compare the management of solid waste and sewage among Canadian cities.
9. Explain the major elements of urban biodiversity and how it can be better managed through the naturalization of habitats.

Introduction

The Development of Urban Areas

Urban areas are cities, towns, and other places where people live in a compact population. Most urban people are engaged in economic activities that function efficiently in dense populations, such as commerce, education, manufacturing, and services. In contrast, resource-based economic activities, such as cultivating food and harvesting
minerals, fossil fuels, timber, or wildlife, occur primarily in rural areas.

Urban areas import energy, food, and materials from the local countryside, as well as from more distant regions of their country, in addition to other nations around the world in an increasingly global commerce. The resource-related connections between cities and rural areas exist at all spatial scales (local, regional, and global) and are an integral but often insufficiently appreciated aspect of urban ecology.

The development of dense habitations (initially small villages) during human cultural evolution began about 10-thousand years ago, when early agricultural practices allowed the production of local surpluses of food (harvests that exceeded the subsistence needs of the farmers themselves). The excess food encouraged the development of specialized occupations that were most efficiently performed in a central place such as a village or town. New societal activities included organized religion and political systems, artisanal manufacturing, and the means of administering these over wide areas through hierarchical economic, political, religious, and military structures.

The first villages were probably supported by both settled agriculture and local hunting-and-gathering activities. By about 9,000 years ago, small farming villages were relatively widespread in some regions, particularly in the Fertile Crescent of the Middle East (see Chapter 24). By 8,500 years ago, that region boasted sizeable walled towns. Similar developments also occurred in China and probably elsewhere in southern Asia.

From these humble beginnings, urbanization of the human population has proceeded apace, and especially rapidly during the past century. Only about 2.5% of the human population lived in towns and cities in 1800, and 5-10% in 1900. Today, about half of the human population lives in urban places, and this is predicted to rise to two-thirds by 2025 (or about 5 billion people). About 90% of this increase in urban populations will occur in less-developed countries (see Chapter 10). Globally, the urban population is now growing about four times as quickly as that of rural areas, largely because of the migration of huge numbers of people from the countryside to built-up areas.

In Canada, about 20% of the population lived in towns and cities in 1871, increasing to 38% in 1900, 63% in 1950, and 81% in 2011 (of which 45% live in cities larger than 750-thousand people; Chapter 11).

In 1750, few cities supported more than 50-thousand people – London was the only one in England, and there were none in North America. In 1830, New York and Philadelphia were the only American cities with a population greater than 100-thousand. By 1910, however, 52 cities in North America supported more than 100-thousand people (New York was the largest, with more than 1 million). In 1950, New York and Tokyo were the only two megacities in the world (that is, having a population greater than 10 million). In 2014, there were 537 cities supporting more than 1 million people, including 35 megacities, of which 29 were in the developing world (Brinkhoff, 2015). The largest megacities are listed in Table 10.5.

No effective discussion of urban population policies has occurred in any country. Consequently, no population policies exist for urban areas in Canada or elsewhere. The key issues are how large should cities be in order to provide people with safe and clean places to live, while also supplying the goods and services that urban areas can deliver most effectively? If the largest cities are considered overpopulated, how can continued population growth be discouraged? Can people be encouraged to move to smaller centres? These and other questions related to urban population policies are extremely controversial, but all will have to be addressed.

Image 25.1. Urban environments are highly artificial. This shopping atrium in Toronto has semi-natural light, an
atmosphere that is temperature-controlled for comfort, some potted plants (all tropical species), a flock of fibreglass Canada geese, and an overall ambience that is contrived to stimulate consumerism. Source: B. Freedman.

Urban Ecosystems

Any urbanized area can be viewed as being an ecosystem, because it has the following ecological attributes:

1. a need for enormous inputs of energy and materials to sustain its human population and its diverse economic activities, and to maintain its structure and grow
2. a complex metabolism, including well-developed webs of transfer, processing, and storage of materials, energy, and information among interacting organisms and economic sectors
3. and immense outputs of heat and other waste materials, which are disposed of in surrounding ecosystems, causing pollution and other environmental problems

Of course, the habitats of cities and towns are very strongly influenced by human activities. Collectively they comprise an urban–industrial techno-ecosystem (Chapter 8). The structure of this anthropogenic ecosystem is dominated by the businesses, dwellings, factories, roads, and other infrastructure of the human economy, while also supporting manicured green space as well as remnants of natural habitats in parks and other less-developed spaces. Although humans are
the dominant species in the urban ecosystem, many other species are also supported, most of which are not native to
the region. Important ecological functions also occur within the urban ecosystem, such as biological productivity and
water and nutrient cycling, but these processes are greatly influenced by humans.

All urban areas are intrinsically dependent on surrounding ecosystems to provide them with necessary resources and to
assimilate wastes that are generated. The ecological footprint (or eco-footprint) of an urban population is the area of
ecoscape (landscape and seascape) that is needed to supply the necessary food, energy, materials, waste disposal,
and other crucial goods and services. As a global average, the average human has an eco-footprint of about 2.7
hectares, but there are only 1.8 ha of bio-productive land and water on Earth (Ewing et al., 2010). This means that the
human enterprise has already overshot global bio-capacity by 30%, and is now operating on an unsustainable basis by
depleting the remaining stocks of “natural capital”. Note that, in the context of ecological footprints, these data are
measures in “global hectares” (gha), which represent the average productivity of all bio-productive habitats on Earth or
in a country, including agricultural land, forests, and fishing grounds, but not including desert, glaciers, or the open
ocean.

An average Canadian has an ecological footprint of about 7.3 global hectares (2007 data; Ewing et al., 2010). This is the
seventh-most intensive national per-capita footprint in the world, after the United Arab Emirates (10.7 gha), Qatar (10.5
gha), Denmark (8.3 gha), Belgium (8.0 gha), the United States (8.0 gha), and Estonia (7.9 gha).

Here are some additional comparisons among wealthier countries: Australia (6.8 gha), Kuwait (6.3 gha), Ireland (6.3
gha), Norway (5.6 gha), France (5.0 gha), Germany (5.0 gha), United Kingdom (4.9 gha), and Japan(4.7 gha). The
rapidly-growing economies include Russia (4.4 gha), Brazil (2.2 gha), China (2.2 gha), and India (0.9 gha).

Of course, people living in poorer countries have much smaller ecological footprints: Afghanistan (0.6 gha), Bangladesh
(0.6 gha), Haiti (0.7 gha), Burundi (0.9 gha), Ethiopia (1.1 gha), Vietnam (1.4 gha), and Peru, (1.5 gha).

The major influences on the differences in these ecological footprints are related to the intensity of energy and material
use and waste production within the national economies. The per-capita ecological footprint of Canada is about 7.0
global hectares per person, while the bio-capacity is 14.9 gha (Figure 25.1). The major elements of the footprint are
related to emissions of carbon dioxide (a greenhouse gas; this is known as the “carbon footprint”) and activities
associated with harvesting or otherwise damaging forests and engaging in agricultural and fishing activities. The major
contributions to bio-capacity are ecosystem services related to Canada’s extensive areas of forest, agricultural land, and
fishing grounds. Overall, the bio-capacity of Canada is about double the ecological footprint.

Figure 25.1. The Ecological Footprint of an Average Canadian. The data are in percentages, based on the relative
contribution of each category to the (a) per-capita ecological footprint or (b) the bio-capacity of Canada. The data are
related to the area of bio-productive habitat that is needed to provide resources and to assimilate waste products. Note
that the data for the carbon footprint are the hectares needed to provide fossil-fuel CO2 offsets, such as the area of
forest whose productivity compensates for the energy content of an amount of fossil fuel used, or that fixes atmospheric
CO2 at a comparable rate. Source: Data from Ewing et al. (2010).
Based on the Canadian national footprint of 7.0 gha, the ecological footprints of Canada’s five largest cities (population data from Table 11.4) are the following (data are in millions of hectares):

1. Toronto 39.1
2. Montreal 26.8
3. Vancouver 16.2
4. Ottawa-Hull 8.7
5. Calgary 8.5

These footprints are about 71 times larger than the actual areas of these cities. Without such enormous regions to draw upon for resources, these and all other urban areas would be unable to survive.

The Organization of Cities

Urban Planning

Urban ecosystems have extremely complex structures and functions (although not more so than natural ecosystems).
To some degree, their development has occurred in an orderly fashion, with certain areas being designated for particular kinds of structures and activities. Urban planning is the active process of designing and organizing the structure and function of cities. As such, urban planning contributes to the information needed by legislators and other decision makers as they develop sensible and efficient siting of the following:

- buildings, including homes, commercial properties, institutions (such as hospitals and schools), and industrial facilities
- infrastructure for transportation, utilities, and waste management, such as roads, railways, public-transit routes, electrical transmission and pipeline corridors, sewers and sewage-treatment facilities, and solid-waste disposal areas
- greenspaces, including playing fields and horticultural and natural-area parks

Well-planned urban areas have relatively pleasant neighbourhoods where people live and work. In contrast, poorly planned cities are chaotic, dirty, and unpleasant. In general, urban planning is most effective in wealthy developed countries such as Canada, but much less so in poorer developing countries where the population is growing and urbanization is proceeding most rapidly.

The dominant planning paradigm of the past 60 years has involved the segregation of major land-uses and economic activities into different areas. This kind of strategy has greatly influenced the design of modern cities, including all those in Canada. It has resulted in many urban people living in discrete inner-city neighbourhoods or more distant suburbs, while shopping in large malls, working in factory or office complexes and industrial parks, and commuting long distances among these land-use types. However, this type of planning has contributed to some important urban problems, including the following:

- the rapid growth of huge, multi-city, urbanized regions (sometimes known as conurbations)
- the inefficient segregation of residences from places of work and commerce
- long commuting times for workers
- congested transportation systems
- a decay of neighbourhood life
- environmental problems such as air and water pollution, wasteful use of energy and materials, paving of valuable farmland (many urban areas are located on excellent agricultural land), and losses of natural habitat

Some of these issues are examined in more detail later in this chapter.

The paradigm of widely segregated land-use is now being challenged by the concept of a more integrated “neighbourhood” design. This involves the development of relatively compact, self-sufficient communities that contain a mixture of residential and commercial land-uses. In some respects, this harkens back to more traditional elements of community design, in which housing, employment, local commerce, small-scale manufacturing, and recreation were all within easy walking distance. The re-emergence of this concept in urban planning has been substantially influenced by the ideas of Jane Jacobs, a geographer who taught at the University of Toronto.

**Urban Land-Use**

Urbanized areas cover about 20 000 km² of Canada, only 0.2% of the total land. Canada is, nevertheless, a highly...
urbanized country because 81% of its population (about 22 million people) lives in cities and towns.

Although patterns of land-use vary among cities in Canada, the dominant uses are for residential, commercial, industrial, and transportation purposes (Figure 25.2). As such, urban areas are mostly occupied by: single-family homes, duplexes, and apartment buildings; commercial, industrial, and institutional buildings; parking lots and paved roads; and other built structures. Non-paved areas are mostly grassy lawns. All of these urban “habitats” are highly anthropogenic in character – they are, after all, places where large numbers of people live, work, and play. Some urban greenspaces also contain habitat for elements of native biodiversity, as we examine later.

Figure 25.2. Land-Use in Some Canadian Cities. The data show the percentage distribution of land-use in 1995. Note that the cities do not all report comparable units: Vancouver and Ottawa do not report agricultural land, and Toronto includes parks in institutional use. Source: Data from National Round Table on the Environment and Economy (1998).

Environmental Issues 25.1. Urban Sprawl

Canadian cities are growing rapidly for two reasons: (1) most immigrants
prefer to live in urban areas, and (2) there is immigration from rural districts. Both of these groups are seeking economic opportunities, as well as the cultural and lifestyle benefits of living in large centres. In any event, because of the rapid population growth, urbanized areas are spreading into adjacent rural habitats, a phenomenon known as “urban sprawl”.

All cities and towns in Canada are located on land that was formerly occupied by natural ecosystems. However, much of the sprawl that is occurring today involves the conversion of agroecosystems into urbanized areas. When the agricultural land is lost, there is a depletion of the ability of the landscape to provide food. This is an important problem in parts of southern Canada, where much of the highest-capability land in the country is being converted into residential and commercial uses of cities.

Urban sprawl is also a threat to natural habitats, particularly in areas that sustain rare ecosystems. For example, the area around Victoria is the only place in Canada where dry forest dominated by Garry oak (Quercus garryana) occurs. This is habitat to many rare species and is one of our most endangered natural ecosystems. The expansion of residential areas is the greatest risk to this coastal oak forest. Conservation agencies in government and the private sector, including the Nature Conservancy of Canada, are trying to protect the surviving patches of this rare forest.

Urban sprawl can also be a threat to the ability of landscapes to provide key environmental “services,” such as clean water. One such case involves an area known as the Oak Ridges Moraine, which has become a rallying point for habitat protection against further urbanization in the Greater Toronto Area. The moraine is a 160-km-long, 1950-km$^2$ ridge located north of the city, and it is composed of hilly terrain underlain by glacial sand and gravel. Because of its rough topography and poor fertility, much of its area has remained forested or is used for pasture or other low-intensity agricultural purposes. Groundwater originating in the moraine is a source of well-water recharge for about 250-thousand people and is a source of 65 rivers and streams and many wetlands. However, with the rapid growth of the greater Toronto region, the moraine has been subjected to increasing pressure from residential and commercial development. Extensive clearing of its forested and pasture areas would degrade the ability of the moraine to provide clean groundwater for use by people and to support streams and wetlands. Loss of the remaining forest would also destroy habitat for native species that are rare in the region.

In response to intense lobbying from groups seeking to limit new developments on the moraine, the Government of Ontario formed an advisory panel to provide advice about the regulation of land-use. The panel provided many recommendations, including the need to protect 92% of the moraine from intensive development, and these were key in the preparation of The Oak Ridges Moraine Conservation Act, 2001. The Act was used to prepare a land-use plan, including provisions for core natural areas and linkages among them, comprising about 62% of the moraine. In 2002, the premier of Ontario announced the formation of a non-profit Oak Ridges Moraine Foundation and provided it with $15 million to fund public education, monitor the moraine, develop trails, and secure natural habitats. The federal government also announced that land it owns on the moraine, about 30 km$^2$, would be kept as greenspace. In addition, the Nature Conservancy of Canada has been acquiring properties of high conservation value and is setting them aside as protected areas.

These are positive actions, although there is still pressure from some landowners to allow more residential and commercial development in the area. Fortunately, however, these pressures have mostly been resisted and there is continuing progress in the conservation of greenspace in the Oak Ridges Moraine.
Urban Transportation

All urban areas have complex systems for moving people and goods. The physical infrastructure for transportation includes roads, parking lots, railroads, subways, airports, and water routes, plus the many kinds of vehicles that operate on these corridors. From the turn of the twentieth century to the 1950s, public transit systems were the most commonly used means of longer-distance personal transportation in Canadian cities. Public transit is still an important means of transportation in cities, although its growth is moderate and not nearly as impressive as that of automobile use (Figure 25.3).

Figure 25.3. Changes in Urban Transportation in Canada. The data show the trends in the use of urban transit systems and in automobile ownership. The jumps in the data series in certain years reflect changes in the ways that the data were reported. Source: Data are from Statistics Canada (2006, 2014) and APTA (2014).

Most urban transportation involves the use of motorized vehicles (Figure 25.4). On average, about 93% of passenger-kilometres are travelled by private vehicle (car or light truck), and only 4%, by bus; 3%, by rapid transit and rail; and less than 1% by other means (such as bicycles). About 75% of trips are made by car or truck; 14%, by public transit; 10%, by walking; and 1%, by bicycle. In general, larger cities have a better developed infrastructure for public transit. For example, in Metropolitan Toronto, 65% of total trips are by automobile or small truck, 30%, by public transit, 4%, on foot, and 1%, by bicycle (NRTEE, 1998).

Figure 25.4. Means of Transportation in Some Canadian Cities. Data are for 1995 and are the percentages of the total passenger-kilometres travelled within the various cities. Source: Data from National Round Table on the Environment and Economy (1998).