1 Town, Village, and Land Spatial Patterns

We live so near the flowers in the fields,
So near the howling wind in forest spires,
And the gentle waves, lapping at the shore,
We live so near.

Paraphrased from a Scottish ceilidh song by
Buddy MacDonald, 2018

"So you want to see the land of towns and villages?"

"Sounds good."

"You're at the right place (rural Iowa, Midwestern USA), and Bertha here is the way to go."

My friend and I stand near a giant blubbery-looking object in bright earth colors and bulging from the ground. It shivers. Filling with air, the thing gets huge. A tiny basket hangs from the bottom, and the friendly aeronaut captain nimbly hops in. Quickly he starts the power. Whooeeesh-sh-sh-sh-sh. Gas-fired flames shoot a few feet upward into the mammoth oval.

"Hop in. Those harnesses will hold you. We can control going up and down somewhat, but horizontally, we go with the wind."

Upward we rise. It's absolutely silent up here. Except for the occasional bursts of fire. Whoeeeeeeeeeeessssh. Captain keeps looking sideways at clouds, distant smokestacks, a grassfire, another balloon, a group of circling vultures. Detecting winds of different directions and speed at different levels. We go up a bit to better wind.

I'm surprised by the array of neat farmsteads, all seemingly caught in a web of barbed-wire fences. Endless green pastures – the cows must be happy.

Later we pass lots of striped fields, some with crawling tractors. We look directly down on woods and streams. But towns and villages are the real eye-catcher from up here.

Now back on the ground, we can explore the land of towns and villages with a worldwide literature, rich in useful concepts, models, principles, ideas, and uncertainties. We start with five perspectives: (1) framework; (2) town sizes, types, and forms; (3) anatomy of towns and villages; (4) land surrounding towns; and (5) hybrid natural–Euclid patterns.

Framework

Diverse, big-picture perspectives get us into the subject: (1) a big picture; (2) why important?; (3) a good place to live; (4) problems living here; and (5) features affecting nature in town.

A Big Picture

More and more of the world's people, increasingly squeezed into urban areas, have never lived in a town. Some have never seen a town or village. Others escape briefly from the city. Nonetheless, more of us know less and less about the land of towns and villages upon which we all depend, fundamentally and daily.

Towns appear in countless forms – old and new, small and large, growing and shrinking, industrial and coastal, on and on. What do we know ecologically about these population centers, and their effects on the land? Amazingly little. Ecological *terra incognito* surrounding us – a giant frontier.

A *town* is a compact mainly residential area in agricultural or natural land that contains about 2,000 to 30,000 residents and a local government. Towns are larger than villages and smaller than cities, and usually have a major economic activity other than harvesting surrounding resources. In contrast, a *village* is a group of households with a public building(s) and about 200 to 2,000 residents, and well separated from town or city.

Not just small places, towns and villages act as key hubs of the global land surface, the essential centers of daily activities affecting the land (Figure 1.1). Nearly half the world's population lives in rural or remote towns and villages. Everyone depends on the activities of "townies," not only for food and wood products, but for freshwater, air quality, flood control, biodiversity, recreational opportunity, and glorious landscapes.

Meanwhile cities dominate our headlines. Urban areas mushroom worldwide, with rural to urban movements, informal squatter settlements, outward sprawling, creative innovations, economic engines, social dynamism, magnets for conflict, and mammoth environmental problems. Many ecologists also turn to urban areas as scientific frontier, with good science contributing to solutions for stubborn societal problems.

Towns (and villages) differ in numerous distinctive characteristics from city-centered urban areas, from farmland, and from natural land. An extensive literature highlights the important social, economic, cultural, and aesthetic dimensions of towns (Nolen, 1927; Francaviglia, 1996; Young, 1999; Wilder, 2013; Albrecht, 2014). But syntheses even introducing ecological or environmental dimensions are indeed scarce (Pysek and Pysek, 1990; Sargent *et al*., 1991; Pysek and Hejny, 1995; Friedman, 2014; Fallows and Fallows, 2018).

Consider a town linked with its surrounding villages, farmland, and natural land. This distinctive *town-centered area* differs markedly from forest, desert, crop field, pasture, and urban areas. Adding town-centric areas together forms the *land of towns and villages*, which covers perhaps half the global land surface, is home to nearly half the world's population, and provides essential resources to everyone else concentrated in urban areas.

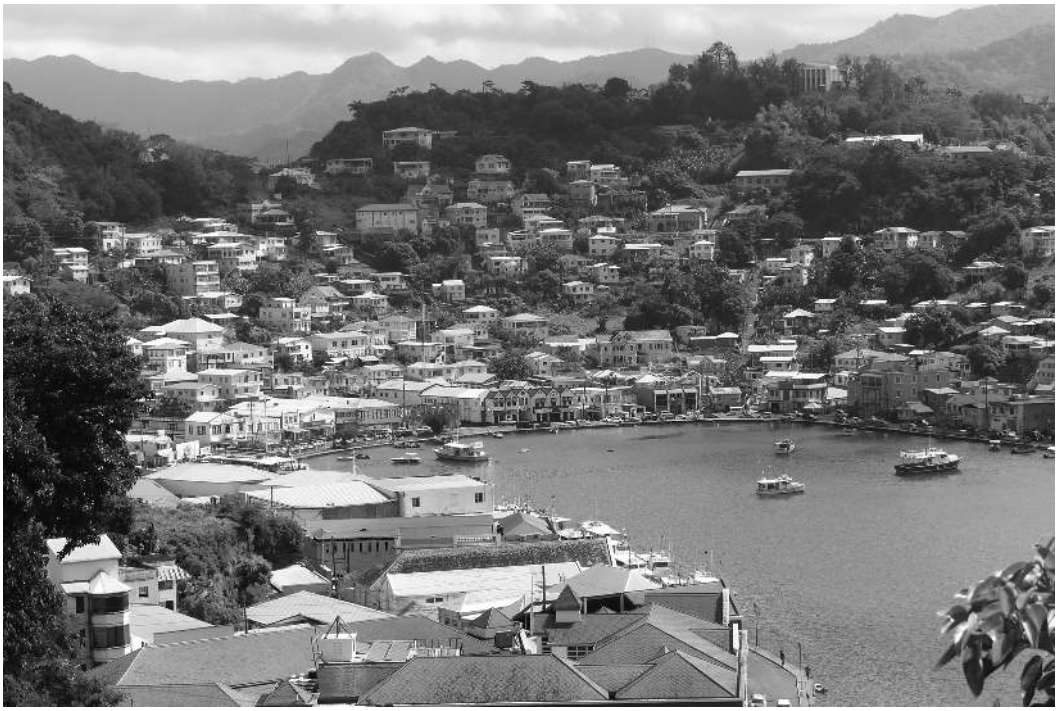

Figure 1.1 Town on amphitheater-like slope descending to harbor with boats for fishing, tourists, or shipping goods. St. George's, Grenada, W.I. See Appendix. R. Forman photo. (A black and white version of this figure will appear in some formats. For the color version, please refer to the plate section.)

Urban areas cover a few percent of the land, and natural landscapes remote from towns and villages cover nearly a quarter of the land surface (Muller and Werner, 2010; Hoekstra *et al*., 2010). Apparently, almost another quarter is pastureland distant from a community. Yet within some regions and mid-sized nations, about 90 percent of the land surrounds towns (Ratajozak, 2013).

This is the area of active human activity, where local people from towns and villages live, grow crops, tend livestock, and harvest wood. Both local and urban residents recreate here.

Town ecology refers to the interaction of organisms, built structures, and the physical environment in population centers of about 200 to 30,000 (villages and towns), and their interactions with the surrounding agricultural or natural land. This concept follows from the basic concept of *ecology* (interactions of organisms and the environment). Also, it builds from the scientific concepts of *urban ecology* (interactions of organisms, built structures, and the physical environment, where people are concentrated), and an *urban region* (area of active interactions between a city and its surroundings) (Forman, 2008, 2014). Analogous definitions apply to the ecology of villages and smaller hamlets.

A central dimension of the land of towns and villages is the interaction between towns/villages and surrounding land. A population center (community) affects the land, and, vice versa, the land affects the community. Town and land are tied together, usually tightly.

Consider a desert town that owes its existence to water (Figure 1.2). An adjoining river provides irrigation water by canal for vegetables, hay, and livestock. Water from a nearby mountainside provides a water supply for residents. Key resources from high school and hospital to industrial center and dump are close by in the town's adjacent zone. The town serves six nearby villages.

Diverse flows and movements connect town and land. Consider a few entering a town: dust, seeds, floodwater, herbivore pests, farm machinery, and rural shoppers. Conversely, flows/movements from town to surroundings include: workers, recreationists, sewage wastewater, industry air pollutants, town species, traffic/trucks/noise, and school buses. Some effects, including stormwater, air pollutants, and sewage wastewater, mostly impact the area close to a town. Yet others, such as groundwater, dust, manufactured products, and vehicle traffic, may continue on beyond even to cities.

Early geographic spatial models provide valuable insights into the general patterns present. *Von Thunen bands* (Cronon, 1991) refer to the concentric zones of influence around a town. Characteristic bands from town edge outward are: intensive gardens/orchards; cropland; livestock pastureland; and wooded land for hunting and wood products. Of course, the concentric bands are commonly modified by topography, such as mountain, river, and coast.

Another spatial model, *central place theory* (Christaller, 1933), adds insight. Where many population centers are present, each is a central place from which socioeconomic effects such as manufactured products, newspaper coverage, and school districts extend outward, creating a so-called hinterland around the center. Where population centers are close together, they compete and surrounding spaces are relatively small and typically devoted to agriculture.

A spatial polycentric hierarchy is superimposed on these broad patterns (even perhaps in suburban landscapes; Harris, 2015). Population centers of different size, i.e., town, village, hamlet, and crossroads, form the hierarchy (Arendt, 2004; Hough, 2004; Friedman, 2014). Smaller population centers tend to be denser near a larger center. Thus, the land has many towns with clusters of small centers nearby each. Few small centers and normally little human activity modify the land far from towns.

Most population centers originated where farmers settled near the confluence of good soil and a waterbody (Figure 1.3). Thus, over time most towns and villages are mainly surrounded by agricultural land, beyond which is natural or semi-natural land such as woodland/forest or desert. The population centers act as local nuclei with effects extending across the land. Although environmental, economic, social, and cultural dimensions differ markedly in different geographic regions (Forman, 2014), these spatial patterns of population centers and land are widespread, even universal.

Why Important?

Urban areas cover a few percent of the land surface, support a bit more than half the human population, and are growing fast in both population and especially area. Society's attention and funding are increasingly focused on the urban area, both to improve

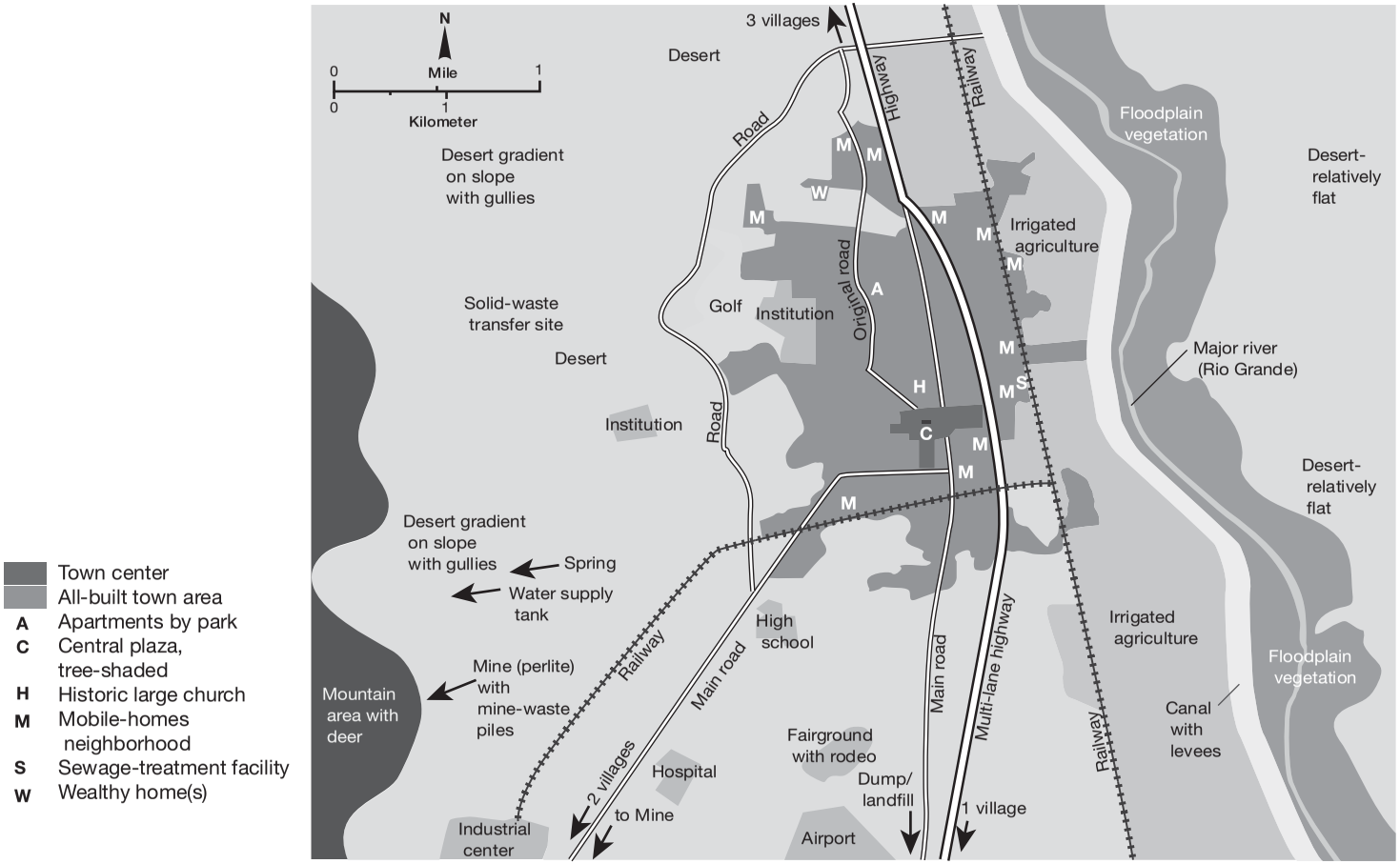

Figure 1.2 Desert town by major river and transportation corridors. Socorro, New Mexico, USA. See text and Appendix. (A black and white version of this figure will appear in some formats. For the color version, please refer to the plate section.)

Figure 1.3 Village with most families returning from city on weekends/holidays to join 89 residents. Abanades, Castilla y La Mancha, Spain. R. Forman photo. (A black and white version of this figure will appear in some formats. For the color version, please refer to the plate section.)

services and increase opportunities. Addressing the large and numerous environmental urban problems is also increasingly on the radar screen.

At the other end of the spectrum are remote natural landscapes which still cover large expanses. Generally of low economic value or too remote, these areas receive little attention and protection. Yet, they are of global importance as reservoirs of clean water, stabilizers of weather patterns and clean cool air, absorbers and storage of greenhouse gases, protection against massive soil erosion and sedimentation, and reservoirs of native wildlife and biodiversity. Furthermore, these large remote natural areas are sources of inspiration for people who treasure them or venture into them for recreation.

The massive middle ground, the *land of towns and villages* where small population centers predominate, is the highlight here. This is home for half the world's people, and provides jobs for almost all of them. Croplands produce most of the food on the table, both for rural centers and urban areas. Pasturelands produce the meat for both targets. Most of society's wood products come from this land. Almost all nature-based recreation for local residents and for urban dwellers exiting a city occurs in this land.

This land of small population centers typically cools the air, facilitates precipitation, absorbs and stores carbon. It is the prime determinant of how much human-caused soil erosion by wind and water occurs. Indeed, the extensive fertile soil loss into rivers and sea basically originates in the agricultural landscapes.

The bulk of the land's biodiversity is present in the land of towns and villages. Doubtless many species of tundra and ice are missing from this area of human activities. Also, a small number of species especially sensitive to human activity are probably missing. But basically, all generalist species are present, some of which benefit from and are attracted to areas of human activity. Also, most specialist species are present at least in low population size in patches within areas of human activity.

In essence, the entire human population depends intensively for food and resources on the land of towns and villages. The environmental dimensions of the area are priceless in their own right, and also intensively affect the entire globe. Understanding the ecological patterns, processes, and changes in this people-and-nature area should be a priority.

Features Affecting Nature in Town

All parts of town are close to the surrounding land, which is commonly agriculture. Typically natural land is farther out, but often readily accessible and used by residents. Small patches and corridors serving as stepping stones in farmland enhance interactions between town and wildlife. Animals with home ranges of more than about 1 km^2 (250 acres) are particularly sensitive to these surrounding patterns.

Towns are located to somewhat fit with the surrounding topography. The town edge is heterogeneous and porous. Relatively few greenspaces, none large, are present in town. Few major green corridors exist. Mature trees are widespread in the older residential area. No extensive impervious surface area is present, so excessive heat buildup and stormwater runoff are much less of a problem than in cities. Towns have limited shallow underground infrastructure, though breaks occur that commonly pollute groundwater. Numerous and diverse microhabitats are present and readily colonized by species from the nearby surroundings.

Towns are suitable habitat for generalist farmland and natural-land species, which readily colonize town areas. Residents plant nonnative and native species, and transportation carries in spontaneous species. But unlike cities, where ships, aircraft, trains, and trucks provide a major stream of incoming nonnatives, and where urban environmental conditions are so inhospitable for species of natural ecosystems, ecologically towns are somewhat closer to agricultural and natural areas. Unlike many cities with extensive descriptions of the nature present, the nature in towns is scientifically little known (Hanski, 1982; Pysek and Pysek, 1990; Pysek and Hejny, 1995).

Town Sizes, Types, and Forms

Arguably towns differ from one another more than do cities. Thus, we examine the town types and forms as follows: (1) differentiating village, town, and small city; (2) types of towns; (3) town shapes and associated processes; and (4) small cities.

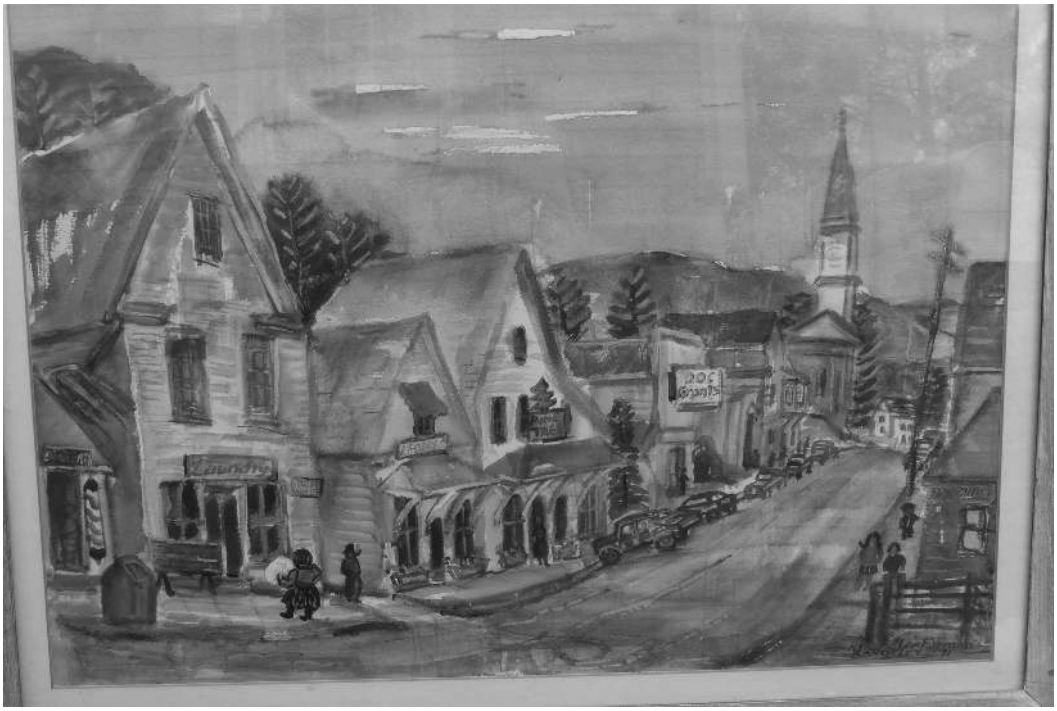

Figure 1.4 Main Street with several local shops of village in forested mountains and lakes. Rangeley, Maine, USA. See Appendix. Watercolor by H. Chandlee Forman; R. Forman, owner. (A black and white version of this figure will appear in some formats. For the color version, please refer to the plate section.)

Differentiating Village, Town, and Small City

Villages see moon and stars down to the horizon. Towns watch the Milky Way when sky arches overhead. Cities delight in a star or planet that penetrates the heavy gray.

Hamlets, villages, towns, and small cities are all population centers or communities (Figure 1.4). *Population center* is a spatially separate compact group of inhabitants or residents, while *community* emphasizes the network of social interactions among the inhabitants that produces collective local action.

Population centers or communities from small to large can be differentiated in several ways, including: (1) area; (2) population density; (3) population size; (4) governmental administrative, functional, and locational criteria; (5) grid and mathematical measures; and (6) bioassays. The first two have important ecological implications but are less commonly used in comparative studies. Governmental criteria and names, such as market town in Britain (McGranahan and Marcotullio, 2005) and contrasting sizes of communities, e.g., called cities in Portugal and China, vary widely from nation to nation. Grid measures, for instance with geographical information systems (GIS) (Sorace and Gustin, 2009; Atkinson-Smith, 2014), commonly split a compact community into two or more grid cells. A mathematical formula illustrated by 2, 4, 8, 16, etc. (Forman, 2014) is non-spatial and doesn't mimic biological or social patterns.

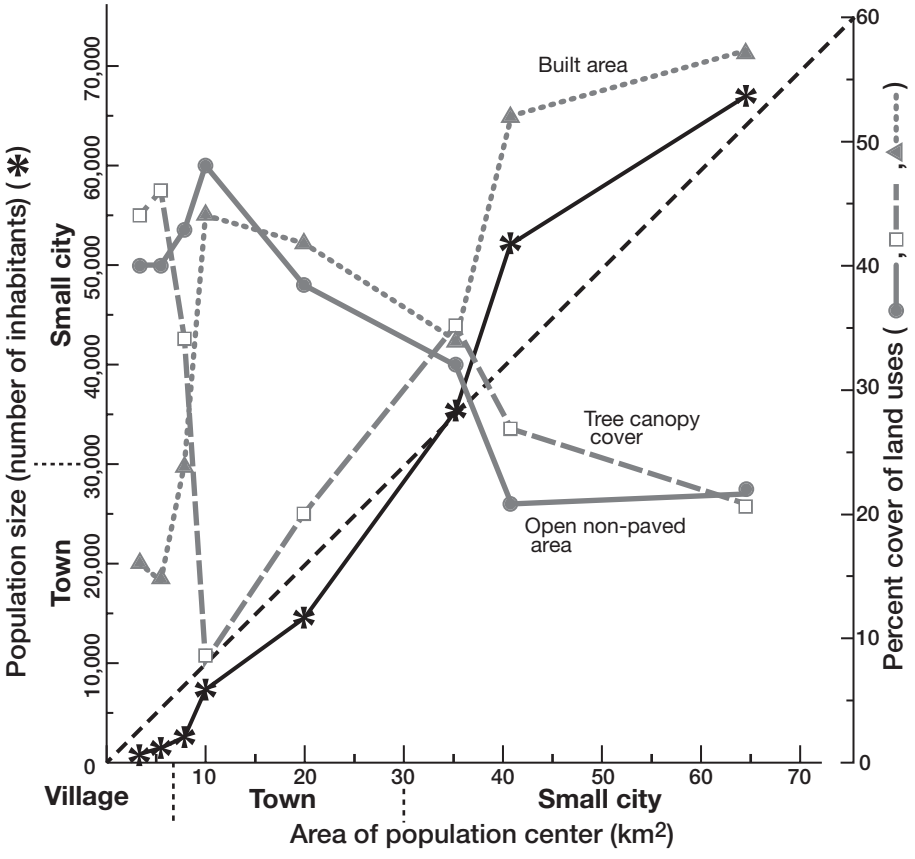

Figure 1.5. Population size and land uses in villages, towns, and small cities. Diagonal line indicates 1,000 residents/km^2. Area of eight communities in the east-central Pampas Plain of Argentina (small to large: Rivas, Castilla, Rawson, Suipacha, SA de Giles, Chacabuso, Mercedes, Lujan), based on transects containing some agricultural activity and thus are a slight overestimate. Agricultural spaces are omitted in calculating percent cover of land uses (covers). Adapted from Garaffa *et al.* (2009)

In contrast, *population size*, i.e., number of residents, is easily measured and understood, and widely used. Below we will briefly compare the results of population size and the few ecological or bioassay measures. Land uses within a community vary according to population size (Figure 1.5). Yet all communities have a center, e.g., the town center, around which people and activities have evolved. So here we use the number of people aggregated around the center of a compact community as the basic measure.

Villages are smaller than towns, and towns smaller than cities. Cities are often described as small, large, and mega. The dictionary defines *urban* as "of or pertaining to cities," so cities and suburbs are urban, but towns, villages, and hamlets are not. Towns also are commonly differentiated as small, medium-size, and large. Hamlets have a small village-like look, but communities smaller than villages normally have no common building for public meetings (Arendt, 2004). Groups of buildings around a crossroad intersection generally focus around the commercial activity of servicing

travelers where roads intersect. An isolated housing development is typically filled with residents commuting to an urban area. Also, individual homes may be dispersed in the land, such as many farmsteads or even where a hermit resides.

Different nations delineate population sizes and ranges for towns differently, sometimes by government decision, sometimes by simple tradition. Sweden, Switzerland, Belgium, Portugal, and Amazonas commonly consider a community of 10,000 to be a small city, whereas in China a small city may reach 100,000 to 500,000 inhabitants.

The following are representative cutoffs differentiating population centers.

Between town and village. Population 1,000: Wales (Atkinson-Smith, 2014). 1,500: England (Sharp, 1946). 2,000: USA (US Census Bureau, 2016); China (Peter Rowe, 2017 personal communication; and Jianguo Wu, 2017 personal communication); Argentina (Garaffa *et al.*, 2009). 2,500: Canada (Friedman, 2014); Europe (Friedman, 2014). 3,000: Poland (Ratajczak, 2013). 4,500: Northern Ireland (Atkinson-Smith, 2014). 5,000: Europe (Vaz *et al*., 2013a); Poland (Vaz *et al*., 2013a).

Between town and city. Population 5,000: developing nations (Hardoy *et al*., 2001; Bell and Jayne, 2006). 10,000: developing nations (Hardoy *et al*., 2001); Europe (Friedman, 2014). 20,000: developing nations (Hardoy *et al*., 2001; Satterthwaite, 2006); North Region of Brazil (Browder and Godfrey, 1997); widespread (Muller and Werner, 2010). 25,000: Canada (Friedman, 2014); USA (US Census Bureau, 2016). 50,000: Europe.

This sample from the literature indicates that the median cutoff differentiating town from village is 2,000–2,500 people, and separating town from city is 20,000. Developing nations tend to have lower numbers (Satterthwaite, 2006). For different administrative reasons, China and Britain for years included much larger population centers as towns. Finally, cutoff numbers tend to increase over time as global population rises.

In the Paleolithic era, 15,000 years ago, human aggregations or "villages" had about 6 to 60 families, while in Mesopotamia some 5,000 years ago, hill villages were of about 200–500 people (Mumford, 1961). In the 1940s commonly an English village had 100–1,500 people and a market town 2,000–20,000 (Sharp, 1946), while today some market towns exceed 100,000 people. Four decades ago (Northam, 1979) population sizes were given as follows: hamlet 16–150 people; village 150–1,000; town 1,000–2,500; and small city 2,500–25,000.

Cultural and socioeconomic dimensions strongly imprint a town. Nearby towns tend to share many such characteristics. As cultural influence spreads, town forms spread across the land (Figure 1.6).

Plant diversity and avian communities correlate with population size of communities (Garaffa *et al.*, 2009). Plant species richness correlates with village size (Hanski, 1982), and in communities from 25 to 45,000 people (Pysek and Hejny, 1995). Generalist and specialist predators correlate with population size (Sorace and Gustin, 2009). A bioassay or ecological pattern could be used to help differentiate village, town, and city.

For instance, in northern Argentina, 52 bird species were encountered along gradients from the center to the outside of nine communities: two villages (populations 472, 827);