Chapter 3

Green Networks

Urban river and stream networks can become an essential structuring element of a city, can be beautiful, and can be the sustenance of a rich urban ecology.

W. E. Wenk, “Toward an Inclusive Concept of Infrastructure”

Urban green spaces include everything in cities that has vegetation. Either natural or planted, green spaces range from potted plants to forests. Through green spaces, people relate to nature in the city. Urban green spaces currently serve many important ecological roles, but they can be designed and managed to do it far better. They can cleanse and return water to the ground, where natural rainfall should go. They can mitigate the urban heat island and reduce the need to heat and cool buildings. They can provide habitat for urban wildlife. They can clean the common pollutants associated with vehicles and roads, both by taking up some of the gases associated with air pollution and by cleaning stormwater runoff. Finally, their green wastes, such as yard debris, can be composted and used to rebuild urban soils.

As a term, “urban green space” is roughly analogous to the more commonly used term “open space,” by which most people mean undeveloped land or land without buildings, roads, and parking. Viewed positively, the terms refer to yards, parks, greenways, and natural areas. However, the term “open space” is perhaps a problem. Taken literally, “open space” implies absence—places left open or vacant in the spatial fabric of a city. Some open spaces are indeed just that. But they are also much more, and the term encompasses a far greater diversity of types, sizes, shapes, and functions than its simplicity implies. Open space might be your yard, the park, the playfields or the garden down the street, the square at the town center, the river corridor that runs through town, or the prairie at the edge. It might be “open” but also complex and highly developed (engineered and built) to perform particular recreational, aesthetic, agricultural, practical, or ecological functions. Open spaces can and do support a diversity
of human uses as well as environmental functions, and their vitality influences quality of life as much as it does the integrity of land, air, and water and forest resources. They do environmental work (Figure 3.1; Table 3.1).

In recent years, landscape architects have drawn attention to the fundamental role of urban open spaces to reestablish the hydrological balance that is seriously impaired in most cities. Planners and ecologists have argued for its equally important role in reestablishing healthy wildlife habitat. A city’s green spaces can and should be employed to harness natural processes in the service of the urban environment. They can serve as “working landscapes” to clean sewage and urban runoff; clean, store, and infiltrate rainwater in ponds and wetlands; and provide space for flooding while also offering beauty, respite, wildlife habitat, and recreation.

The term “green infrastructure” has become a popular catchphrase used to refer to the environmental services or work of urban landscapes. In 1999, the (U.S.) President’s Council on Sus-

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Sustainable Development defined green infrastructure as “the network of open spaces, airsheds, watersheds, woodlands, wildlife habitat, parks, and other natural areas that provides many vital services that sustain life and enrich the quality of life.” Although this definition was not specific to urban areas, urban foresters have used “green infrastructure” to refer to the environmental services that urban forests provide to cities. Conservationists Mark Benedict and Ed McMahon define green infrastructure as “an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations.” This definition is somewhat parallel to what landscape ecologists would call the urban landscape’s “ecological structure” (discussed later in this chapter). Various other disciplines are picking up the term “green infrastructure” to suggest equal value for landscapes as for gray infrastructure such as sewers and roads—or, conversely, to suggest the greening of conventional gray infrastructure. If “infrastructure” is the underlying framework that provides vital services for the city and if “green” is a contemporary colloquialism that means environmentally friendly or healthy, then a better definition for “green infrastructure” could be the green framework that performs a multitude of vital environmental services in cities.

With this broad, inclusive definition for “green infrastructure” in mind, we use the term “green networks” to refer to the geography of open spaces, such as parks, greenways, and natural areas. “Green networks” is narrower in definition than “green infrastructure,” because these spaces are predominantly the public realm and, as such, are important elements of land use and community planning and design. “Green networks” as a term and a concept is flexible and encompassing. While it primarily includes the urban elements of parks, greenways, and natural areas, it might also include many other green elements, such as parkways, green streets, and utility and drainage corridors that serve environmental as well as human purposes. Green networks can be seen, mapped, and traversed by people and animals and, thus, experienced and appreciated. They are physical elements of the city that can be planned for alongside streets and development. In ideal circumstances, green networks are the urban version of Benedict and McMahon’s “interconnected network of green space that conserves natural ecosystem values and functions and provides
associated benefits to human populations.” In actual fact, the
green networks of most neighborhoods and cities are piecemeal
and fragmented, although many cities aspire toward more inter-
connected systems of public open spaces (Figure 3.2).

If green networks are understood to be a city’s public open
spaces, then “green infrastructure” can be used to refer to the en-
tirety of urban green spaces. Green infrastructure would include
public open spaces, the urban forest that extends throughout the
city, and the private landscapes of commerce, industry, and homes.
Green infrastructure describes function. It is, as planner Timothy
Beatley describes, all of the working landscapes in cities that serve
significant infrastructure-like roles, including mitigating air pol-
lution, cleaning water, and controlling floods. The green infra-
structure does part of the work of running a city and helps to
make the city less dependent on its region for water and waste
disposal in particular. Infrastructure, whether gray or green, has
never been conceived or designed to serve ecological functions;
however, this may be one of our biggest oversights of the past and
one of our best opportunities for the future. The services of na-
ture in the city have great potential. As we study cities from an
ecological perspective, it becomes clear that a green infrastruc-
ture, which explicitly serves natural functions, is needed to make
cities more sustainable. This, in turn, suggests an ecologically
based approach to city planning and building as a whole.

**Fragmented Systems**

The history of parks in North America includes many important
lessons as well as visionary works by notable landscape architects
and planners, including Frederick Law Olmsted, the Olmsted
Brothers, George Kessler, H.W.S. Cleveland, and Charles Elliot.
Boston’s Emerald Necklace, designed by Frederick Law Olmsted
from 1878 to 1890, is generally recognized as the first intercon-
connected park system in North America. It was also the first green
network intentionally designed to solve flood and water pollution
problems while also serving recreation and civic purposes. Other
plans soon followed, including ones for Minneapolis
(H.W.S. Cleveland; see Figure 3.3), Buffalo (F.L. Olmsted), and
Kansas City (George Kessler), and twenty years later, for Seattle
Most of these plans took advantage of existing natural resources—such as river corridors, lakes, and hilltops—for aesthetic, social, and recreational purposes. Although not driven primarily by environmental concerns, the landscape architects nonetheless saw both human and natural values in creating interconnected green networks.

Visionary park system planning, land acquisition, and development work in North American cities was nearly halted during the Great Depression and World War II, save for projects done by the Civilian Conservation Corps and the Work Projects Administration. In the early postwar period, suburbanization outpaced the ability of most cities and counties to plan for and acquire land for parks systems. In 1962, the Outdoor Recreation Review Commission reported that America’s population was outgrowing its outdoor resources. The early 1970s saw a brief rekindling of interest in interconnected park systems, but soon thereafter cuts in the Land and Water Conservation Fund by the Carter administration and the recession of 1982 put an end to that movement. In 1985 the President’s Commission on Americans Outdoors once again emphasized the value of interconnected greenways and proposed a national system of greenways within and between cities. Some cities embarked on greenway programs in the early 1990s, but it was not until environmental imperatives of the later 1990s, such as the implementation of the EPA’s urban stormwater management program, added urgency that many more cities once again began to plan urban greenways. In the meantime, the rapid and extensive expansion of urbanized areas had broadly affected ecosystems in their surrounding regions.

Sprawling urban development has also contributed to the most significant ecological problems of the twenty-first century: habitat loss, habitat fragmentation, and the related loss of ecological biodiversity. For example, the U.S Geological Survey estimated that wetlands in the United States were lost at a rate of more than 60 acres per hour for the two hundred years from 1780 to 1990. California has lost 91 percent of its wetlands. The U.S. Fish and Wildlife Service estimated a net loss of 117,000 acres per year of wetlands from 1985 to 1995, 21 percent as a result of urban development. In Oregon, no significant areas of

Figure 3.3 Minneapolis park system designed by H.W.S. Cleveland. (Source: Heckscher and Robinson, Open Spaces)
the original oak savanna habitat that once covered the Willamette Valley remain. While much of this loss can be attributed to agriculture, urban development of these landscapes clearly plays a role as well.

Urban development contributes to the fragmentation of ecosystems because it separates habitat patches and breaks ecological connectivity. For example, in the Willamette Valley in Oregon, the state’s three largest cities—Eugene-Springfield, Salem, and metropolitan Portland—straddle the Willamette River. Riparian habitat has been reduced to little or nothing along many urbanized portions of the river, fragmenting the riparian corridor along its length. At the same time, development has separated the forested uplands and many remaining wetland areas from the primary ecological corridor of the valley, the Willamette River.

**Engaging Landscape Ecology**

An ecologically based approach to city building, one that begins with an understanding of cities as a part of nature, engages nature and natural processes to help sustain the city. Taking this approach to city planning implies “moving beyond separate visions for human and nature while recognizing that humans are a key species in contemporary earth ecosystems,” or, as architect William McDonough says, cities could be places of nature. In other words, an ecological approach views human ecology and natural ecology as interacting partners in the local ecosystem.

Such an approach to the design and planning of urban systems would allow natural processes to continue in a more ecologically healthy state, would produce fewer negative impacts on the urban environment itself and the surrounding region, and, particularly, would recycle urban wastes, all while also allowing for the healthy sustenance of its human populations. Timothy Beatley calls this approach “green urbanism,” which he points out is a “different new urbanism, a new urbanism that is dramatically more ecological in design and functioning and that has ecological limits at its core.” A common example of this approach includes recycling programs for both manufactured and green urban wastes. In this case, the energy embodied in these materials
is recycled within the urban ecosystem, not exported to another more rural ecosystem that cannot use it. Contemporary, and still experimental, water management programs that reuse gray water or that clean and infiltrate stormwater runoff help to maintain the urban ecosystem’s water balance, reducing the need to import clean water and export polluted water.

To take an ecological approach to designing and managing the urban environment, each city’s unique landscape ecology must be understood. Whereas ecology is the deep study of individual ecosystems or populations, landscape ecology is the broad study of heterogeneous land areas composed of a cluster of interacting ecosystems. Landscape ecology studies three characteristics of landscapes: structure, or the spatial relationships among the distinctive ecosystems or landscape elements present; function, or the interactions among the spatial elements, such as flows of energy, materials, and species; and change, or the alterations in landscape structure or function over time. The city is a unique ecosystem, derived from historic landscapes yet changed by urban structures and processes. The complexity and the vast extent of the urban environment coupled with its rate of change and the need to get ahead of that change makes this discipline appropriate for studying urban landscapes.

Landscape structure is the pattern and relationships among the many landscape elements or individual ecosystems that make up a larger, more complex landscape. Landscape structure can be seen from the air and, as such, can be mapped and measured. It is composed of the overall or predominant matrix, which is interrupted by patches of different habitat types or areas and connected by linear corridors. In the rural landscape—the focus of many of landscape ecology’s founding studies—the predominant matrix would be cultivated fields interrupted by patches of habitat, such as forests and wetlands, that are interconnected with corridors, such as riparian corridors and hedgerows. In the city, the landscape matrix is urban development interrupted by similar remnant habitat patches (e.g., forests and wetlands) that are interconnected with corridors, such as riparian corridors, drainage ditches, and utility corridors. The effective ecological structure of the city, the patches and corridors of natural landscapes, would roughly equate to the green networks described in this book.
Green Networks and Form

Landscape structure is a useful planning tool. Much of the work in urban land use planning involves identifying patterns of development or preservation and the allowable uses for particular parcels of land. Setting aside lands for their important ecological functions remains a fledgling process, one struggling against a legal history that protects individual property rights and previously projected monetary values. In the United States, such federal laws as the Clean Water Act and the Endangered Species Act have allowed protection of habitat and water resources to become a part of urban planning in many cities.

Some urban ecologists are developing methods to prioritize those remaining elements of landscape structure and process that, taken together, are vital to the long-term health of the urban ecosystem. Conservation organizations such as the Nature Conservancy often focus on saving whatever vestiges of endangered or threatened species that exist. However, some argue that—from a planning perspective—a longer-term view toward ecosystem sustenance may be more important. In Planning for Biodiversity, Sheila Peck suggests that at the landscape scale, conserving representative samples of community types as well as functional relationships and physical connections among them is most important. Preserving large blocks of remaining open space and preserving the opportunity for disturbance and hydrologic processes to continue are also high priorities for protection. Within this broad range, certain landscape types have been recognized as special priorities; for example, “species-rich” and viable natural areas may be of highest priority. Species-rich landscapes are most commonly riparian and wetland areas in which water is available and which contain a complexity of vegetation and of wildlife species. Viable natural areas are areas that contain primarily native species and that require little human input to sustain them. Within these broad parameters, an ecological planning methodology would engage both scientists and the general population to help identify and prioritize the essential natural areas deemed worthy of conservation.

Beginning with a full understanding of the ecological structure, functions, and processes of an urban ecosystem would be the preferable approach to initiating ecologically based planning.
for a city. Unfortunately, full knowledge of an urban ecosystem is typically considered unachievable because of ongoing planning and development. In every city, innumerable parallel planning efforts are under way at any given time, including planning for land use, transportation, infrastructure, economic development, and open space. Although ecologists might argue that ecosystem planning should occur first, it rarely leads these efforts. Perhaps the first task in urban ecological planning is to create a sketch of the urban area’s ecological structure as represented by the remaining riparian corridors, wetlands, meadows, and forests. Natural hazard areas, such as floodplains, landslide areas, or earthquake faults, may also be included. The resulting sketch—reviewed and refined through public process and adopted as an open space vision by representative agencies—would become a framework for various deeper studies, for protection and restoration efforts, and for multifunctional planning of many aspects of urban development (Figure 3.4).

A city’s riparian corridors might be seen as the “trunk lines” of the city’s green networks. Although reduced in area, fragmented, and often invaded by nonnative plants and animals, these corridors usually are highly valued by urban populations and also serve important hydrological and habitat functions. They are fragments of the landscape’s former structure, still needed to perform the work that much more extensive natural areas once did. Riparian areas are linear, and as such they typically also provide connectivity between larger habitat patches. This contributes to the long-term viability of populations, particularly in fragmented landscapes such as cities.

Planning efforts that study the ecological structure of the urban region and develop plans for metropolitan-scale green networks can guide green network planning at the city, neighborhood, and site scale. Within the context of the region, each city, each urban watershed, each neighborhood, and each site can create a vision for a greener future. In Portland, Oregon, the Metropolitan Greenspaces Program is working successfully toward preserving key armatures of the region’s ecological structure, including riparian areas, wetlands, and upland forests. The program grew out of an initiative by the Portland Audubon Society in the late 1980s to establish an interconnected system of natural areas primarily to support wildlife habitat. This vision was coupled with
other local open space initiatives, and a first step in the process, a natural resources inventory, was done by Metro, the regional planning and public services district. By 1991, the vision had become an official program of Metro, and the multi-objective Metropolitan Greenspaces Program was born. A master plan was completed in 1992, and after one false start, a major land acquisition bond measure was passed in 1995. Clearly rooted in the original vision of preserving a metropolitan area–wide, interconnected system of natural habitat areas, the program’s goals also now include preserving the diversity of plant and animal life, restoring natural areas in heavily built up neighborhoods, establishing an interconnected trail system, and encouraging environmental awareness and public knowledge about the regional green spaces.

Between 1995 and 2001, Metro either purchased outright or otherwise protected through easements nearly 7,000 acres of natural areas throughout the region, including wetlands, riparian areas, forests, and meadows. The program now boasts an extensive list of partners, including virtually all of the counties and cities in the Metro region. Guided by the natural resources inventory and the Metropolitan Greenspaces Masterplan, these local jurisdictions and some independent land trusts have acquired additional lands to help complete the green network. While far from encompassing a protected and fully interconnected ecological structure, Portland is well on its way to reaching its goals, with significant segments of the many target areas now under public ownership or otherwise protected. In 2003, the Greenspaces Masterplan was being updated and two narrower plans—water quality and floodplain protection plan and a fish and wildlife habitat protection plan—were being developed.

The visionary framework provided at the regional scale by the Greenspaces Masterplan has had a direct impact at the city and neighborhood scales. Villebois, a redevelopment project under construction in the suburban city of Wilsonville, south of Portland (see the case study in Chapter 2), provides an example of a smart growth community that engaged the Metropolitan Greenspaces vision and incorporated restoring landscape and making ecological connections into its plans (Figure 3.5). The Villebois project sits at the southern edge of the Tonquin Geologic target area of the Metropolitan Greenspaces Program. The area includes unique historic geologic features sculpted by an-
cient glacial flooding. Coffee Lake basin is the dominant natural feature targeted by the plan for acquisition, and portions of it immediately north of the Villebois site have been purchased by Metro. Land south of the Villebois site, called the Wilsonville tract, which would help to connect the Coffee Lake lands to the Willamette River corridor, are also owned by Metro, allowing the development project to make important ecological connections. In addition to protecting more of the Coffee Lake wetlands, the development plan includes a broad greenway designed to connect the Coffee Lake wetlands and the Wilsonville tract at the south. Together, the Coffee Lake area, the Villebois greenway, and the Wilsonville tract comprise more than 500 acres of wetlands, riparian corridors, and upland forests located in a rapidly suburbanizing area (Figure 3.6). The plan exhibits a rare and relatively recent phenomenon of intentionally using redevelopment projects to restore and reconnect ecological structure.

### Connecting Region to Neighborhood

Landscape ecological studies can be conducted at nested scales. In the urban environment, these might start with the landscape region in which the city resides and progressively go down in scale to the metropolitan area, the major drainage basins, the districts or subdrainage basins, and the neighborhoods. The cross-scaled nature of such studies can inform the cross-scaled nature of urban planning and design, in which only certain questions are addressed at the regional or metropolitan scale and others are addressed at the city or neighborhood scale. What may be considered essential ecological structure at the metropolitan scale, for example, may in fact be destination habitat patches at the district scale. Patches and corridors that clearly exist and have ecological value at the neighborhood scale may be too insignificant to consider at the metropolitan scale. For example, a small grouping of native trees (a patch) and vegetated drainage swales (corridors) that are found at the neighborhood scale may hold no importance at the metropolitan scale, yet these small vestiges of habitat and corridor may contribute significantly to the overall functioning of the urban landscape by providing otherwise nonexistent connections.
Within and among the metropolitan region’s ecological structures lies the fabric of the city. Planning and designing neighborhoods involves the detailed layout of this fabric, including the green and gray networks and the development parcels between them. In the United States and Canada, development occurs primarily in the private sector. Within a general land use and transportation framework of geography and policy, developers typically do the detailed planning that occurs at the neighborhood scale. Local governments can guide the physical form of neighborhoods through policy, regulation, and incentives, and in some cases local governments perform detailed advanced planning to demonstrate how to carry out policy. This neighborhood scale of planning and design is the focus of this book. It is where great potential exists to integrate or merge the green and the gray.

At the scale of the neighborhood, functioning natural areas should be protected and, where possible, interconnected with a region’s ecological structure, such as rivers and large natural areas. Isolated patches of habitat (e.g., minor wetlands, remnant forests, or meadows) can be connected using the neighborhood’s green network, drainage and power corridors, greenways, bikeways, and other linear parks. If designed to engage nature and natural processes, these green networks can contribute to the ecological functioning and health of the neighborhood. Added together, heterogeneous “bits of nature” (such as a patch of native trees) connected by green networks contribute far more significantly to regional ecosystems. At the same time, they provide invaluable resources for residents.

While the larger-scaled ecological structure in urban areas may well serve primarily ecological functions, neighborhood-scale green networks, finely woven into the urban fabric, must serve many varied roles equally. As William Wenk says, the complexity of contemporary cities places a higher responsibility on public open space to serve multiple civic functions. If the whole of the city’s green network is understood to include a multiplicity of public green space—such as parks, school grounds, remnant natural areas, bikeways, drainage corridors, utility corridors, and even some streets—the primary role of each space will differ. For example, although its primary role may be channeling stormwater, a drainage corridor can also clean polluted water as
well as provide civic improvement, public accessibility, education, and habitat. Wenk’s design for stormwater gardens along the greenway at Heritage Park, pictured here, does exactly that (Figure 3.7). Urban green spaces, which should be dedicated to multiple uses and defined broadly, will likely require the partnership of numerous city agencies to create and manage them.

Using an ecologically based approach would allow neighborhood designers not only to understand and address a site in its social, economic, transportation, and land use contexts but also to study its current or potential contributions to larger-scaled ecological structure and functions as well as its ability to mitigate the development’s future environmental impacts. The site itself, or the local context, may suggest opportunities for the neighborhood’s green infrastructure that may, in turn, help to shape the neighborhood’s layout. For example, degraded agricultural ditches or a fragment of a former stream corridor may provide the inspiration and incentive for restoring riparian corridors and a healthy local hydrology.

In one example, remnant ditches, headwater streams, and wetland—as well as an important hydrological position in the landscape—all pointed toward planning a surface drainage system for the East Clayton neighborhood in Surrey, British Columbia. In this plan, streets, parkways, multi-use green corridors, stormwater wetlands, protected riparian zones, parks, and school yards all work together to form an interconnected green network aimed at diminishing the typical impacts of new development on water systems (Figure 3.8). The plan, prepared in 2000 by the University of British Columbia James Taylor Chair in Landscape and Liveable Environments for the City of Surrey, was developed with a specific intent of demonstrating sustainable development principles, addressing Greater Vancouver’s Livable Region Strategic Plan, and protecting the Green Zone (described below).35 The site is located upstream of two of the region’s significant natural resources, the Nicomekl and Serpentine rivers, both of which flow into Boundary Bay, a significant tidal estuary. Headwater streams flowing into these rivers pass through the site. Sustainable development principles agreed to in advance by community stakeholders guided the planning and design process. These principles called for a compact, walkable neighborhood with a diversity of dwelling types, a well-connected street network...
of narrow, treed, pedestrian-friendly streets with rear alleys for automobile storage and services, and the preservation of natural resources and natural drainage systems.

The 618-acre site will eventually be home to about 13,000 people. Under construction in 2005, the compact, mixed-use community will include a broad range of housing types, from rental apartments to both attached and detached single-family homes. A neighborhood commercial “main street” along the western edge of the community, mixed-use residential areas within the community, and a business park will provide services and jobs for residents. A finely grained, grid-based street network with alleys will provide high levels of connectivity for vehicles, pedestrians, and bicycles while also serving utility and environmental functions.

Protecting the headwater streams that flow into the Nikomekl and Serpentine rivers was a high priority for East Clayton. To that end, principle 7 read: “Preserve the natural environment and promote natural drainage systems.” Designers used three primary strategies to fulfill this principle: (1) protecting and enhancing on-site stream and drainage corridors, (2) promoting a surface drainage system aimed at maintaining the site’s predevelopment hydrology, and (3) limiting the amount of impervious surface in the development. The green network on the site knits together a system of “riparian” neighborhood and school parks with both naturally existing and constructed riparian corridors and stormwater wetlands. Even the street system is designed to contribute to environmental goals. These “green streets” will provide a secondary green network for the neighborhood (Figure 3.9). As designed, narrow, curbless pavement drains to adjacent infiltration swales, which are lined with generous tree-planting areas. This diverse, finely scaled network of green infrastructure in the neighborhood performs environmental services that help protect the region’s ecological structure.

Developed between 1991 and 1996 as a component of the Livable Region Strategic Plan, Vancouver’s Green Zone is a regionally scaled vision of ecological structure that provided a context for the East Clayton sustainable development plan (Figure 3.10). In 1991, the metropolitan region around Vancouver, British Columbia, was projected to grow by 1 million people in thirty years. Currently, it is home to about 2 million people and is pro-
jected to grow to 4.8 million by 2100. The urbanized area already encompassed the full extent of land between the U.S. border and the mountain ranges that limit northern growth. With an ocean to the west, suburban expansion had nowhere to go but eastward along the Fraser River Valley, an area of prime agricultural land serving much of Canada and beyond. In a reversal of typical growth management planning, the Greater Vancouver Regional District (GVRD), the regional planning authority, began planning for an additional 1 million people in the landlocked lower mainland by first engaging the region to identify the Green Zone—"globally significant" natural resources that were in need of protection from urban development. The Green Zone includes community health lands, such as the city’s watersheds located in the North Shore mountains and floodplains; ecologically important...
lands, including the forested mountain slopes, wetlands, and important ecological corridors; outdoor recreation and scenic lands, including parks and trails; and renewable resource lands, including agriculture and forestry lands (Figure 3.11). The Livable Region Strategic Plan, adopted by GVRD in 1994 and by all member municipalities by 1996, emphasizes four strategies: protecting the Green Zone, building complete communities, achieving compact development, and increasing transportation choices.37

Vancouver’s Green Zone is a crude yet visionary sketch of the metropolitan region’s ecological structure. Conceived in advance of regional growth management and transportation planning, it guides ecological planning efforts at many scales. The East Clayton neighborhood, a mere pixel on regional plans, responded directly to the Livable Region strategy and the Green Zone. Its finely scaled green network of streams, drainage ways, and wetlands will help preserve a healthy hydrology and provide small corridors for ecological connectivity while also serving multiple human purposes.

As discussed above, cross-scaled ecological planning is beginning to show results in Portland, Oregon, and Vancouver, British Columbia. In both cities, regional policies and plans have identified and prioritized protection of the region’s green networks. The cities in each region have responded with plans of their own, for which they encourage or mandate compliance. In both cases, regional and city plans provide information and a framework for neighborhood-scale plans, such as Villebois and East Clayton. Neighborhood-scale networks may be primarily streets, bikeways, drainage corridors, or open space, yet they can contribute significantly to the functioning and health of the neighborhood when they serve multiple human and natural functions. Most important, by allowing natural processes to occur within and along these corridors and networks, the neighborhood’s green networks can contribute to a healthy metropolitan ecosystem.

**Green Networks Strategies**

- Create a vision for protecting, restoring, and interconnecting the city’s ecological structure.
- Identify and plan multifunctional green networks at every...
planning scale: the metropolitan area, the city, and the neighborhood.

- Engage the research community and the citizenry to study the city’s ecosystem and the elements of its ecological structure.
- Employ landscape restoration to repair the torn and fragmented fabric of the structure.
- Incorporate natural processes in the design of urban landscapes, and make these natural processes visible.
Chapter 5
Gray Fabric

fabric \ ˈfa-brik \ noun . . . the arrangement of physical components in relation to each other

Just as neighborhoods are the building blocks of cities, individual lots are the building blocks of neighborhoods (Figure 5.1). These lots, accumulated into city blocks where people live and work, create the urban fabric. This fabric is composed of shops, services, and offices (commercial uses); schools, community centers, and government offices (civic uses); warehousing and factories (industrial uses); a broad range of housing types; and parks and open spaces. Urban fabric lies between the green and gray networks and is connected by them. Because it is fully integrated with the green and gray networks in a city, it should always be planned as a part of the whole system. This chapter focuses on the built-up, gray urban fabric, while the next chapter considers the green urban fabric.

Sprawl, with its roughly two-to-one ratio between land consumption and population growth, has become the norm in North American cities, largely because of low-density development patterns (Figure 5.2). These widely dispersed and disaggregated land uses are connected by automobile-friendly but pedestrian-unfriendly networks. Two building patterns predominate in these landscapes: ever-larger single-family homes on individual plots of land and what are commonly called “big box” commercial services, which are large, single-purpose retail outlets sitting in the midst of very large surface parking lots. These low-density, sprawling development patterns have high environmental impacts while concurrently degrading people’s health and quality of life. These impacts are clearly demonstrated in terms of their ecological footprints, or impacts on regional and global resources. An average working resident of Vancouver, British Columbia, living in an average suburban, single-family home and driving about 300 miles per week has an ecological footprint of 11 hectares.

Figure 5.1 Gray fabric shown across scales from the yard to the city.
(27.2 acres). If that same person lived in a smaller, attached home closer to work, substituted some trips each week with walking or transit, and reduced driving to about 185 miles per week, he or she would reduce this ecological footprint to 6 hectares (14.8 acres)—clearly an improvement but still not globally sustainable. At the conclusion of their ecological footprint quiz, Redefining Progress states, “Worldwide there exists 1.8 biologically productive global hectares [of land] (4.4 acres) per person.”

The alternative to sprawl is more-compact neighborhood development. Compact development features higher densities; appropriate mixes of land uses (which include employment); a diversity of housing types, sizes, and costs; well-designed circulation networks that prioritize pedestrian and bicycle routes; and parks and open spaces located within walking distance of homes. Contemporary urban design theory suggests that neighborhoods can meet the demand for weekly shopping, recreation, and school trips, and this is particularly so when shopping and services are in close proximity, with easy pedestrian and bicycle access for many neighborhood households. Numerous studies generally agree that these patterns not only consume less land but also can be associated with less automobile travel and therefore less air pollution. Denser communities tend to produce fewer vehicle miles traveled (VMT) per capita. One particular study found that, for a similar set of activities, 1 mile of transit travel in a dense urban area replaces 4 to 8 miles of automobile travel in lower-density suburbs. Others have found that land use patterns that integrate higher-density housing with commercial services and employment and also develop high-quality transit, bicycle, and pedestrian routes can reduce vehicle use. Robert Cervero and Carolyn Radisch found that residents of a traditional streetcar suburb made 28 percent of their nonwork trips by foot as compared to 6 percent by residents of an automobile-oriented development. Others found that the relationship of density to nonmotorized travel choices was nonlinear, with higher densities resulting in even higher rates of pedestrians and bicycles. Planning and design standards are beginning to reflect this linkage. The Institute of Transportation Engineers allows vehicle trip rate reduction factors of 2 to 7 percent in sufficiently dense, mixed-use areas with good pedestrian and bicycle networks, and up to 20 percent when those areas are also served by transit and light rail.
Northwest Environment Watch has compared patterns of growth in northwestern cities using census data and satellite imagery to demonstrate that development pattern and density matter more than raw population growth numbers. For example, between 1986 and 2001, the greater Vancouver area population grew at an average annual rate of 2.6 percent, from 1.4 to just over 2 million. Over roughly the same period (1990–2000), the greater Seattle-Tacoma area population grew by about the same number of people but less quickly, at an average annual rate of 1.7 percent, from 2.5 million to just under 3 million. Because the Vancouver area encouraged compact development patterns more aggressively than did Seattle, the consequences of roughly similar rates of population growth have differed significantly.

Over this period, the proportion of population in the Vancouver area’s compact neighborhoods (greater than 12 persons per acre) increased from 46 percent to 62 percent; the proportion in the densest, pedestrian-oriented neighborhoods almost doubled, from 6 to 11 percent. At the same time, the proportion of people living in car-dependent neighborhoods (fewer than 12 persons per acre) shrank. The Seattle-Tacoma area, on the other hand, has directed less population growth into compact neighborhoods—about 25 percent, or less than half of the Vancouver proportion. The consequence overall is that the developed Seattle area consumes about 75 percent more land per resident than does the developed Vancouver area.

A related comparison of growth patterns in two neighboring areas of Portland, Oregon, tells this story more vividly. The greater Portland area straddles the Columbia River, two states (Oregon and Washington), and four counties (Multnomah, Washington, and Clackamas in Oregon, and Clark in Washington). This area of approximately 1.4 million people (in 1990) grew steadily and rapidly, by an annual rate of 2.4 percent, roughly double the national average throughout the 1990s. That growth rate translates into a population increase of about 100 new residents a day and a total increase of 376,000 new residents by 2000. About 70 percent of these new residents chose to locate in suburban areas of the three Oregon counties. The remainder chose Clark County, in Washington.

This growth precipitated a loss of about 8 acres of farmland and open space per day in the region. However, because Oregon
and Washington manage growth differently, the loss was not uniformly distributed. In general, Oregon has encouraged growth in more-compact developments through a combination of state and local laws, policies, plans, and programs than has Washington. Not surprisingly then, over that same period, the number of people living in compact neighborhoods (12 or more people per acre) in the Oregon counties increased to just over half the total population increase. On the Washington side, population in low-density development patterns (less than 1 to less than 12 people per acre) increased to just under three-quarters of total population growth and required conversion of about 40 percent more land from rural to suburban uses than did the Oregon counties. Had the population choosing the Oregon counties been accommodated in development patterns more like those in Washington, an additional 14 square miles of farmland and open space would have been lost to development.

**Compact Neighborhoods**

Compactness is a precondition for conserving land and encouraging people to get out of their cars. Done in concert with an appropriate mix and intensity of land uses, and with strategically planned and designed green and gray networks, compactness is also a precondition for reducing pavement, automobile trips, energy consumption, and emissions of air pollutants per household. In urban development, the designation “compact” translates to buildings that are tightly grouped and multistoried. Commercial areas are compact when they are composed of multistoried buildings that include a variety of uses (Figures 5.3 and 5.4). For example, a building might have parking underground, retail on the ground floor, offices and restaurants above, and apartments above that. Compact forms of residential development are attached homes, with the smallest and most compact being stacked apartments and the least compact being attached, single-family homes, such as row houses. However, even row houses are three to five times as compact as most single-family homes.

Compactness is a relative measure. What is considered compact in a large city like Vancouver, British Columbia, will vary from what is compact in a small, sprawling city like Boise, Idaho.
In greater Vancouver, two-thirds of the population lives in neighborhoods that exceed 12 people per acre, whereas in Boise, only 7 percent of the population (in 2000) lived at those densities and most lived in neighborhoods with densities of between 1 and 5 persons per acre. What is considered compact in downtown areas varies from what is compact in the suburbs. Vancouver's downtown West End neighborhood, composed primarily of apartment towers, had a 2001 population density of 84 persons per acre, or 55 dwellings per gross acre. However, in Vancouver's suburban area of Maple Ridge, residential densities of approximately 30 persons per acre in its new town center will be considered compact. Even North America's most compact urban areas pale in comparison to many European cities, suggesting that we still have much room for improvement. Our most compact cities, such as New York (8 persons/acre), Boston (5 persons/acre), and the city of Vancouver (9 persons/acre) equal, at best, half the density of such European cities as Amsterdam (20 persons/acre) and London (17 persons/acre).

Density

Density . . . is always a fundamental decision in city design. It sets the framework for all the other features and has far-reaching implications.

K. Lynch, *A Theory of Good City Form*

Common measures of compactness include density and floor-area ratios. Density, the most common measure for residential areas, is the ratio between the numbers of dwellings or persons and the area of land. It is typically measured either by numbers of dwellings per acre (or hectare) or numbers of people per acre (or hectare). “Gross density,” often used to measure the density of large areas, includes the entire area of land, including all land uses (not just dwellings), streets, and open spaces, whereas “net density” typically considers only the land dedicated to residential uses. Floor-area ratio (or floor-space ratio), which compares the developed building floor area to the site area, is more commonly used for commercial and mixed-use areas occupied by multistory buildings.
In North America, very-low-density development includes areas with between 1 and 5 persons per acre. Low-density development includes areas with between 5 and 11 people per acre (approximately 3 to 5 dwellings per net acre), whereas development is considered compact when densities exceed 12 persons per acre (more than 6 dwellings per net acre). Shopping areas with low-density, sprawling development patterns will have floor areas that are far less than the site area (e.g., a ratio of .25 to 1), whereas in compact neighborhood centers, floor area ratios will be at least 1.5 to 1. When net residential densities begin to exceed 10 dwellings per acre, a critical mass of people resides within a reasonable walking distance to support pedestrian-oriented commercial services, viable transportation services, parks, and schools. Planner Eliot Allen recommends that average densities in new urbanist developments should be in the range of 15 to 30 dwellings per net acre, roughly four times higher than conventional, low-density developments.

Not surprisingly, compactness depends on the size and arrangement of residential buildings, on their relationship to one another and to the land. In North America, the most common residential building types include single-family, detached homes on individual lots; various types of low-rise, attached, single-family housing; stacked, walk-up apartments; and high-rise towers. The highest densities—and thus greatest compactness—are typically achieved in neighborhoods populated by high-rise buildings. However, in North America, high-rise housing is considered most suitable for nonfamily households, whereas families and large households are considered better housed in larger dwellings with good access to yards, playgrounds, and gardens.

Many ground-oriented, low-rise forms of housing—such as stacked townhouses, row houses, triplexes, and duplexes—can meet thresholds for compact neighborhoods while also providing such amenities as ground-related entries, private or semiprivate yards, parking nearby, and opportunities to personalize the home and yard. For example, the historic Kitsilano neighborhood in Vancouver, British Columbia, once a neighborhood of large, single-family homes, is now a neighborhood containing a full array of low-rise housing with walk-up apartments, many derivations of attached homes (such as row houses and duplexes), and single-family, detached houses with apartments (Figures 5.5 and

Figure 5.5 Aerial photograph of the Kitsilano neighborhood in Vancouver, British Columbia. Each grid cell equals 1 acre.
5.6). Single-family, detached housing with ground-level apartments is common throughout the neighborhood (as well as in much of Vancouver) (Figure 5.7). Such structures double the residential density and concurrently provide affordable rental housing in desirable neighborhoods. This very walkable, family-oriented neighborhood has a density of almost 30 persons per acre, or 16 dwellings per gross acre.\(^{18}\)

Entire neighborhoods do not need to have the same density; in fact, to achieve housing diversity, densities and types of housing must be varied. “Graded density” refers to the concept of clustering the highest density at and around a mixed-use service center while gradually decreasing residential densities toward the farthest reaches of the neighborhood.\(^{19}\) This strategy maximizes the population near the center while achieving an average density that will support pedestrian-oriented neighborhood services and also provide a range of choices in housing types and costs. For example, to achieve an average net density of about 9 dwellings per acre, detached and attached single-family and multifamily buildings, ranging from about 6 to 20 dwellings per acre of land, can be mixed. Density gradients were proposed by architect Peter Calthorpe for Sacramento County’s transit-oriented developments (TOD) in the late 1980s and referred to as primary and secondary residential areas. Calthorpe’s concept was to include higher-density housing in the primary residential area, closest to the transit station at the neighborhood center. At Laguna West, a TOD started in 1990, housing in the neighborhood center area was to be restricted to walk-up apartments and attached, single-family housing. The lowest-density single-family, detached housing was restricted to the outer perimeter of the development, while the middle distance included a mix of attached and detached homes on small lots. Thus, the smallest proportion of the population would be beyond the walkable range.\(^{20}\)

A similar approach to dispersing and averaging density occurs in new urbanist developments throughout the United States and Canada. Such developments often average 15 to 30 dwellings per acre, using a range of dwelling types and densities. Near town centers, densities range from 20 to 75 dwellings per acre and can be as high as 50 to 100 units per acre in more centrally located communities. Away from the town centers, net densities range from 6 to 25 units per acre.\(^{21}\)
Complete Neighborhoods

The “completeness” of a neighborhood refers to the extent to which daily and weekly needs are close to homes. Mixing places of work, shopping, education, and recreation within a compact neighborhood potentially reduces demand for vehicle trips. Bringing those activities that are interdependent closer together, finely mixing those that are mutually supportive (where appropriate), and connecting all such activities in ways that attract pedestrian and bicycle travel can reduce vehicle use and related emissions and thus improve air quality.

Completeness transcends scales. Within any major metropolitan area, each municipality comprises a number of neighborhoods. Ideally, complete communities will exist at several scales so that the opportunity exists to live close to work. “Complete communities” is a term adopted by the Greater Vancouver Regional District (GVRD) to encapsulate a key principle of that region’s growth management planning. The GVRD plan identifies eight high-density regional centers along existing or planned light rail lines and many smaller district centers. These so-called town centers each serve as the downtown for municipalities whose populations range from 1,500 to 400,000 (excluding the city of Vancouver). The regional growth plan emphasizes that these centers should be complete, meaning that they should include a balance of jobs that are close to where people live and accessible by transit; shops and services near homes; and a wide choice of housing types within and around each center.

The smallest scale of this continuum is the neighborhood, which should also be complete. Complete neighborhoods need to provide day-to-day and week-to-week services, such as grocery stores, banks, medical facilities, coffee shops, restaurants, hair salons, day-care centers, schools, and parks. Although a balance of jobs will not likely exist in every neighborhood, each neighborhood can provide some working space and an appropriately sized commercial and service center in the heart of the neighborhood. Compatible civic uses (schools and churches) and recreational uses (parks and squares) should be nearby. For local stores and services to thrive, potential customers must close enough to sustain them economically. Industry standards propose a minimum of 1,500 households (3,000 to 3,500 people) to sup-
port neighborhood commercial establishments. However, Calthorpe suggests that it takes 10,000 people, or 2 square miles of mixed-density development, to support a full-service grocery store. In terms of how much land is needed for a commercial center, Lynch suggests one-half to two-thirds of an acre (about 20,000 to 30,000 square feet) of local neighborhood commercial space per 1,000 inhabitants.

Recent concepts of neighborhood composition, organization, and design bear similarities. For example, they typically cluster commercial and mixed-use areas at a neighborhood center located close to a major arterial roadway or a transit line (or both). Around the mixed-use center are higher-density residential areas—often stacked townhouses or walk-up apartments. Beyond that, housing densities gradually decrease from row housing to small-lot, single-family homes to larger-lot, single-family homes. Contemporary plans favor grid-based street networks to provide a fine-grained, pedestrian-friendly network with small neighborhood parks at half-mile intervals.

Orenco Station in Hillsboro, Oregon, is a recognized model of this type of TOD pattern (see the case study in Chapter 2). Originally planned for low-density residential development, Orenco Station was then designated as a TOD in the region’s transportation and growth management plans. Under its new

Figure 5.8 Prototype drawing for a complete, compact neighborhood.
designation, Orenco Station was to be a compact, pedestrian-oriented, mixed-use neighborhood of high-density housing, employment, and retail located close to transit. In this development, many of the patterns of TODs came together. The commercial services, located in a four-block area around a main street and a regional roadway, provide numerous essential services and a few restaurants in approximately 100,000 square feet. The development achieves an average housing density of 12 dwellings per acre, triple that of the surrounding developments. Several forms of higher-density housing surround the center, including lofts over retail, live-work stacked townhouses, standard townhouses, and apartments. Beyond that, small-lot, single-family and duplex housing completes the development.

The nearby Intel and Toshiba plants, located north and southeast (respectively) of Orenco Station, provide jobs, as do several other, smaller business and research parks. About 18 percent of Orenco Station residents always commute to work by transit; however, this is not an exceptionally high number by Portland standards. Perhaps more significantly, 69 percent of the residents report an increase in the use of transit since moving to Orenco Station. Overall, Orenco Station demonstrates a model for creating higher-density, walkable neighborhoods in suburban locations. Specifically, it is a popular and very marketable TOD that has modestly succeeded at reducing its suburban dwellers’ reliance on vehicle travel. It is a step in the right direction.

Neighborhood Diversity

Diversity is a measure of ecological health that also applies to neighborhoods. Ecologists have established that a healthier ecosystem will have more plant and animal diversity. In a similar vein, diversity in neighborhoods would imply a physical diversity capable of supporting a diverse human population. Lively, fine-grained, diverse, and self-perpetuating urban areas are generally the models to which urban designers aspire. In a neighborhood, much of the environmental diversity will be generated from the neighborhood center, where a multitude of shops, services, and businesses are near a diverse array of housing types. The mixed-use center has become the common planning tool aimed
at achieving this vibrant diversity, a major challenge of urban design (Figure 5.9).29

Both the new urbanism and smart growth movements recommend a mixed-use center that allows flexible zoning and a diversity of uses.30 Mixing land uses is smart growth’s primary principle, while creating a diversity of housing choices (types and costs) is third on the list.31 Mixing uses in neighborhood centers allows an array of retail, entertainment, business, medical, and social services to coexist there. The greater the diversity of uses that are located in a small area, the more people can do on foot. New Urban News has designated mixed-use retail areas as “main street retail,” after the shopping streets in many small towns and street-car suburbs. These shopping districts are characterized by small retail establishments situated along a pedestrian-oriented street. Larger anchor stores, which are generally needed to attract sufficient customers, may be located on a street corner or street end or behind street-front shops. Many cities are now requiring the presence of retail space along designated shopping streets, and some also require or encourage office and residential space above the ground-floor retail.

Orenco Station’s shopping streets follow this model. Located along the north side of a major arterial roadway, the shopping and mixed-use district is approximately one block deep and four blocks long. A shopping street on the primary north-south axis of the neighborhood forms the center of the district (Figures 5.9 and 5.10). Buildings within the district are two or three stories, with retail at grade and offices and dwellings above. Within this area are most of the weekly services the residents need, including a grocery store, restaurants and coffee shops, specialty shops, dry cleaners, an optician, a dentist, a psychologist, a stockbroker, and title and real estate offices.32 (As of 2002, residents listed the following services as still needed: bars/pubs, hair salons, a movie theatre, a post office, bookstores, a gas station, a health center, a veterinarian, and a video store.)33 Surface parking for shoppers is located on the streets and behind the buildings along alleys. Immediately surrounding the neighborhood service center is a layer of walk-up townhouses and apartments extending approximately a quarter mile from the center (Figure 5.11).

Blocks adjacent to the shopping street often provide the greatest opportunities for complexity and diversity. This is where
higher-density housing can mix with an array of support services, such as medical and professional offices, hardware stores, galleries, and restaurants. In these blocks, transitions from mixed-use to more explicit housing can occur. For example, the village center for Fairview Salem, a neighborhood planned for Salem, Oregon, exemplifies a mixed-use center in which principles of fine grain, flexibility, and diversity drove the planning. The ecologically based plan primarily strives for economic and social diversity, a goal designers hope to achieve by encouraging a variety of building types and scales to accommodate many uses, including an assortment of shops, services, medical and professional offices, a post office, social clubs, and churches. The planners will encourage economic diversity in the population by accommodating a wide range of housing types and costs, from rental apartments to single-family homes. Business—and thus job—diversity is also a goal. The plan encourages both office and light industry development, some of which will occupy existing buildings. In the village center and in the nearby redevelopment area, planners intend to attract many small environmentally friendly businesses, such as organic food processors, specialty products, and small-scale fabricators (Figure 5.12).

Compact development patterns in complete, diverse communities reduce the ecological footprint per household. Compactness also affords greater conservation of land and landscape character, reduced loss and fragmentation of natural resource areas, and fewer impervious surfaces. Compactness complemented by completeness increases the opportunities to choose transportation other than automobiles, thus reducing air pollution. Specifically, compact development encourages higher rates of walking and cycling, which leads to improved health. Diversity of land uses and housing types provides a context for more vibrant, diverse, and livable neighborhoods.

Compact gray fabric can perform even better environmentally when it is considered an integral part of the city's green fabric. The gray can in fact be green when buildings and sites are designed to conserve or even create energy; to conserve, reuse,
and cleanse water; and to actively engage vegetation that will perform environmental services.

**Gray Fabric Strategies**

- Design compact and complete neighborhoods. Residential densities should be 12 to 30 persons per acre in low-rise areas and 75 to 100 persons per acre in mid- to high-rise areas.
- Make neighborhood services too close to drive to. Establish a fine-grain, diverse, pedestrian-oriented neighborhood service center in the heart of every neighborhood, within walking distance of most dwellings. Cluster compatible schools, churches, and recreational uses nearby.
- Encourage neighborhood complexity and diversity. Surround the commercial and service center with a flexibly zoned area able to accommodate a fine-grained mix of residential and smaller-scale commercial uses.
- Include a diverse mix of housing types and densities serving a broad cross section of households.
- Maximize ground-oriented family housing in most neighborhoods.