

10

Ecologically Based Planning and Design Techniques

Let's return for a moment to Exponentia, our beleaguered community with typical post-1950s, North American development patterns (see Chapter 3). Although Exponentia has a comprehensive plan, zoning ordinances, and even detailed site design standards, the resulting development looks remarkably unplanned. Houses, condominiums, shopping centers, and office parks are separated into single-use pods linked by wide, habitat-fragmenting roads. There is certainly some greenery on the landscape, but aside from a few parks, most of it is leftover scraps of unbuildable land or token landscaped "open space" within developments. What few natural habitats remain are accessible only to salamanders with driver's licenses. Looking east toward the mountains, development is sparser but still regular enough to break up any large blocks of natural land.

Focusing in on individual developments, we see a landscape that has been clear-cut, regraded, and replanted with turfgrass and exotic plant species—a landscape where natural water flows have been rerouted to underground pipes and stormwater detention ponds. These developments are the product of standards and regulations—dimensional requirements, road widths, pipe diameters, curb types, and turning radii for fire trucks—that are exceedingly detailed yet give little regard to the natural environment. We wish that Exponentia were a straw man, a grotesque exaggeration of reality, but in fact this picture should resonate with residents in almost every part of the United States and Canada.

The recent "smart growth" movement is an attempt to address the environmental, social, economic, and quality of life problems associated with growth pat-

terns such as those in Exponentia. Impetus from land use professionals, environmentalists, community activists, politicians, and some developers has prompted major changes in how planning and development occur in some jurisdictions. If nothing else, the smart growth movement has increased public awareness of the costs of poorly planned growth, with articles on sprawl appearing in such popular publications as *USA Today*, *Newsweek*, and many metropolitan newspapers. Yet progress has been spotty, with improvements in some areas offset by stasis or even regression in others. For example, local and state funding for land conservation has increased, but so, too, have vehicle miles traveled per capita and land consumption per capita, two key indicators of sprawl.¹

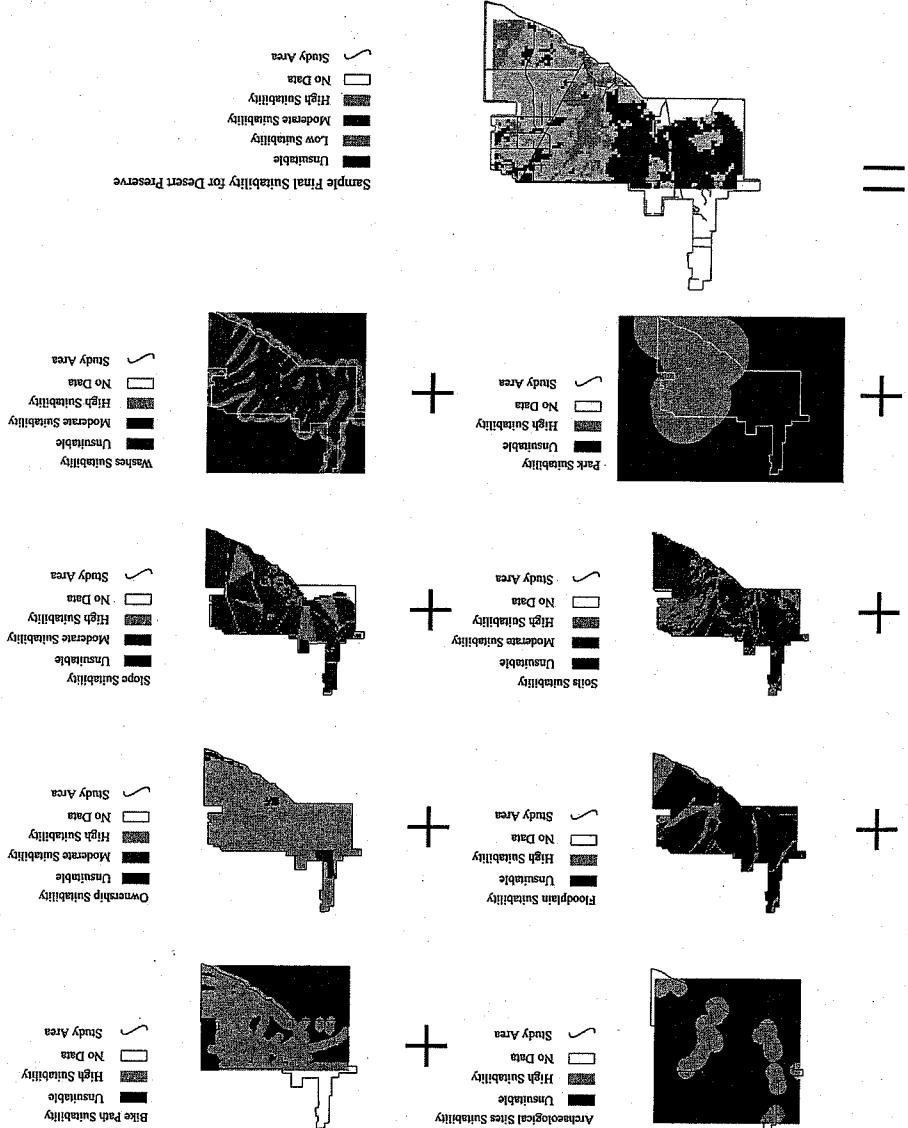
As we discuss in the Introduction, this book focuses primarily on two important aspects of smart growth: (1) addressing the effect of human activities on ecological integrity and biodiversity, and (2) safeguarding humans and their property with regard to the ecological context. In this chapter, we examine some of the more promising smart growth tools and techniques (both established and cutting-edge) available to planners, designers, and developers from the standpoint of these two goals. We begin the chapter by discussing the processes by which ecological data can be incorporated into plans. The next three subsections describe effective planning and design techniques for protecting biodiversity and ecological integrity at three different scales, beginning at the landscape scale (counties and regions), then moving to the sublandscape scale (cities, towns, and counties) and to the habitat scale (lots and sites). You may be familiar with cluster development from the perspective of a planner or developer, but how does it look from the perspective of a turtle? Scientific studies can help answer this type of question, informing the work of land use professionals with reliable information about how better to design for biological conservation.

The final subsection reviews practices for enhancing human health, safety, and welfare in the ecological context. Although we purposely keep discussion of each technique brief and centered on ecology, this ecological focus does not imply that other planning goals—such as meeting society's housing, transportation, and economic needs—are unimportant. The planner's and designer's role is to integrate all of these goals into a cohesive whole—and we hope to advance this process by elucidating one such goal.

Using Ecological Data

In Chapter 7 and again in the planning exercise in Chapter 11, we discuss the types of ecological data that planners and designers should seek to obtain for their site or study area—for example, what species and habitats are present, what types of natural and human disturbances affect the area, and what conditions occur beyond the study area boundaries. Once ecological information has been collected,

Figure 10-1. During the process of land suitability analysis, illustrations for conservation, agriculture, urban development, and other land uses. This type of analysis is a central component of ecologically based planning and design. (Graphic courtesy of Frederick Stemer)



The landscape scale is usually the best scale at which to begin thinking about the conservation of species and ecosystems. As discussed in Chapter 6, landscapes are hundreded miles or kilometers across, examples might include metropolitan Atlanta or Cape Breton Island in Nova Scotia. The landscape scale most often corresponds with the jurisdiction of counties, metropolitan governments, and provinces—almost all of which are involved in some times,

Landscape Scale (Counties and Regions)

an open space planning process. One of the most important places to use ecological data is in the preparation of municipal and county master plans, comprehensive plans, and other long-term plans for natural resources. Many states already require such plans to include a chapter on natural resources or environmental protection, and local and regional ecology should be featured prominently in such a chapter; if not given its own chapter in the plan. This part of the plan should contain an analysis and maps of ecological communities and native species in the jurisdiction, their ecological context, threats to ecological resources, and strategies for protecting local biodiversity and ecosystem functions. This information can also inform the other chapters of the plan, such as a chapter on transportation, energy, and water resources, showing how ecological information can be mapped and analyzed to guide decision making.

But, overall, the technique has changed little since McHarg's presentation in Design with Nature.¹ In this book, McHarg's emphasis was on the relationship between people and the environment, and he advocated a holistic approach to planning that integrated social, economic, and ecological factors. He believed that the environment must be considered in its entirety, and that planning should be based on a deep understanding of the complex interactions between people and the natural world. He argued that planning should be a collaborative process, involving all stakeholders in the decision-making process. He emphasized the importance of ecological sustainability, and he called for a shift away from traditional approaches to planning that focused on economic growth and industrialization, towards approaches that prioritized environmental protection and social justice. His ideas have had a significant influence on planning and design in the United States and around the world, and his legacy continues to inspire new generations of planners and designers.

land use planning. A worthy conservation goal at the landscape scale would be to implement the "aggregate-with-outliers" model (see page 115), in which large contiguous patches of natural or seminatural lands are set aside for such values as core habitat and headwater stream protection. Similarly, large patches of agricultural and urban lands can be designated so as to gain the benefits of aggregating these land uses.

Landscape Conservation and Development Plan

Planning at the landscape scale must address the broadest possible land use question: where should humans build, farm, or ranch, and where should they not? The creation of a *landscape conservation and development plan* (LCDP) can help answer this question in a simple, easy-to-understand format. The LCDP need only consist of four elements: core habitat, secondary habitat, intensive production areas, and urban areas (see Figure 10-2).^{*} Although the LCDP is our term for a plan that blends traditions of conservation planning and large-scale land use planning, such planning is not without precedent. For example, Color Plate 9 is a long-term, large-scale plan for the Portland, Oregon, area that describes general future development and conservation patterns.

The first of the four LCDP elements is *core habitat*.^{**} These are the landscape's system of nature reserves and should be designated based on the location of rare species and habitats, intact natural systems, and lands providing valuable ecosystem services, such as groundwater recharge and headwater stream protection. Landscape ecology principles should also inform the designation of core habitats to create a system that includes hubs (areas with considerable interior habitat), linkages (corridors or stepping stones, depending on the species of concern), and small "outlier" reserves. Not all of the core habitat needs to be in public ownership or protected through outright acquisition; planners can use other land protection strategies, including *purchase of development rights*, *transfer of development rights* (explained later in this chapter), donation of land or land interests, and various types of *conservation easements*. These techniques may allow

* This typology is a variation on the tripartite classification of core habitat, buffer area, and matrix, which some conservation biologists have suggested for conservation planning. However, intensive production areas, such as row crop agriculture and plantation forestry, merit a separate category since they are neither buffer areas (because they offer little habitat value) nor urban areas. Intensive production areas also tend to be an important focus of planners working in rural and semirural landscapes.

** The concept of "core habitat" presented here is different from what many conservation biologists mean when they discuss "core reserves": very large reserves, tens to hundreds of miles or kilometers across, that are off-limits to almost all human activities. While core reserves may be achievable in some areas, they are rarely feasible in the context of planning and design work. Therefore, we focus instead on smaller, more varied core habitats, which are essential to biodiversity conservation and are feasible in almost every jurisdiction, at the scale where planners and designers tend to work.

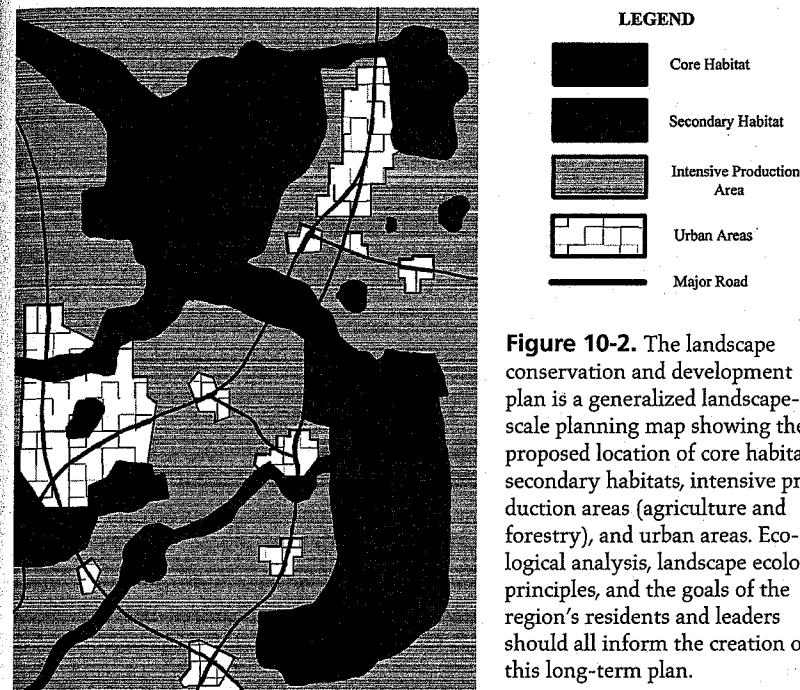


Figure 10-2. The landscape conservation and development plan is a generalized landscape-scale planning map showing the proposed location of core habitats, secondary habitats, intensive production areas (agriculture and forestry), and urban areas. Ecological analysis, landscape ecology principles, and the goals of the region's residents and leaders should all inform the creation of this long-term plan.

for a low level of continued human activity on the land as long as it is compatible with the local ecology.

The *secondary habitat* can be thought of as buffer areas that surround the core habitat. These buffers provide the following ecological values:

- Increasing the quality of interior habitat in the core areas by reducing external impacts to these areas
- Increasing the amount of habitat available to species that can tolerate low to moderate levels of human activity
- Designating large areas that will have near-normal ecosystem functioning (e.g., groundwater recharge).

From a planning perspective, secondary habitat consists of those land uses that generate very modest ecological impacts, disturbing only a small portion of the land in a manner that has no long-term negative effects. For example, low-intensity forestry, very low-density development, and many types of passive (nature-based) recreation could provide secondary habitat, as could low-intensity agriculture that provides significant habitat value.

portant consideration is to designate sending areas to correspond with high-advan-tages.⁴ For protecting biodiversity and ecological integrity, the most im-Several kinds of TDR programs exist, each with its own advantages and dis-

advantages of the protected land.

Long-standing TDR programs, such as those in Montgomery County, Maryland, developmen-t, while additional development can be built in the receiving area. result of the transfer, the land in the sending area is permanently protected from thus transferring those rights from one site to the other (see Figure 10-3). As a rights to develop their land to landowners or developers in the receiving area, is deemed to be desirable. TDR allows landowners in the sending area to sell the discourage development and a receiving area, where higher density development two areas: a development rights sending area, where the jurisdiction wants to designate undeveloped lands at the landscape scale. Most TDR programs designate Transfer of Development Rights (TDR) is another planning tool used to ag-

Transfer of Development Rights

as the one in Gloucester, can help save tax dollars as well as native habitat. draining directly to sensitive salt marshes. Local infrastructure service areas, such undeveloped areas, where they would allow houses to be built on rocky ledges existing wastewater disposal problems but without extending them to nearby areas, which will bring sewer lines to places where they are needed to solve pre-existing wastewater problems such as "sewer sprawl." For example, the city of Gloucester, Massachusetts, has designated "sewer service areas," which will bring sewer lines to the state, county, and local levels. For example, investment can work equally well on the spread-out development on farmland and native habitat. Targeted infrastructure is sited at the periphery of the community and therefore encourages further taken steps to address phenomena such as "school sprawl," in which a new school subsidies to developmen-t in ecologically sensitive areas. Other jurisdictions have grants to strengthen existing human communities while avoiding implicit public by local ecologically based planning. Maryland municipalities can use this program to strengthen existing human communities while avoiding implicit public subsidies to address phenomena such as "school sprawl," in which a new school sewers, and other facilities and programs that support development. Informed cities and towns to identify where the state should focus its investments in roads, habitats areas.

However, since land outside the UGB is not prohibited from human use (for ex-UGB does not eliminate the need for providing additional protection for core ample, much of the land south of Portland is intensively farmed), the use of a related tool, targeted infrastructure investment, directs public infrastructure

areas with suitable location, soils, and topography to support dense development. To achieve this goal, the UGB should be drawn to exclude lands of high ecological value—for example, the core habitat areas in the LCDP—while including desirable aggregate-withouters pattern at the landscape scale (see Figure 6-9). If used properly, UGBs can be an effective instrument for achieving the includes enough land for twenty years of projected growth; thus, it is intended land UGB is reviewed and expanded from time to time to ensure that it always tied to agriculture, conservation, and very low-density development. The Port-land uses outside the boundary are generally limited to infrastructure (high-speed rail transit) to support moderate to North America is in Portland, Oregon. Within Portland's UGB, public funds are prohibited or strongly discouraged. The best-known example of a UGB in map within which development is encouraged and outside of which development is prohibited adjacently adjacent areas. A UGB is essentially a line on the existing cities and immediately surrounding growth into pre-

Urban Growth Boundaries and Infrastructure Target Areas

scape scale plan could be implemented. urban growth boundaries and transfer of development rights—by which a land-politics of how it will be implemented. We move now to two specific techniques—bold vision (connected habitats, contained cities) without first resolving all of the traditionaly abstracted from zoning maps and ordinances. The LCDP is implemented mechanims as zoning maps may be developed, leading ultimately to such detailed local and short-term plans within which more able. As such, it is a larger-scale and longer-term framework within which more tripartian belt or a new satellite settlement (that may not be immediately achievable to twenty-five to fifty years—to envision land configurations (e.g., a restored on transient human considerations, the plan can afford to look far into the future—because it is based more on innate characteristics of the land than should be used. Land suitability analysis identifying how intensively each part of the landscape and sustainability analysis identify baseline land use in the LCDP is essentially a broad-scale As the previous explanation suggests, the LCDP is essentially a broad-scale

trial and nonresidential land uses. would also include most suburbs and would encompass a wide range of residential places where built land has become the landscape matrix. Thus, urban areas all lands to an economically productive use. Finally, urban areas are short-han-d for ing locally produced food and fiber, and limiting suburban sprawl by putting rural target to planners for other reasons, including creating jobs and income, provide three plantations. These areas usually provide little habitat value but are im-pressive production areas include heavily managed agricultural lands and

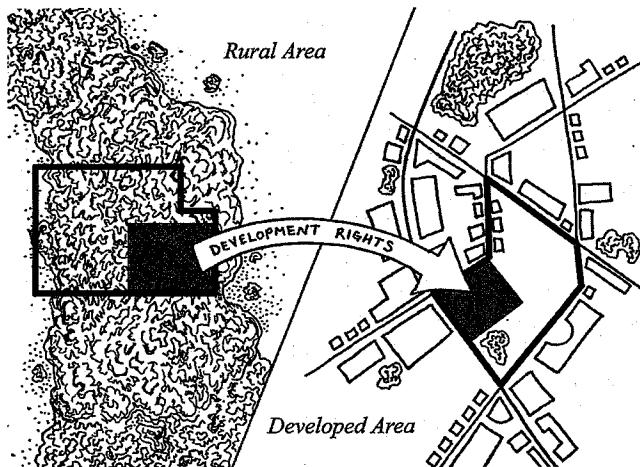


Figure 10-3. Transfer of development rights (TDR) typically allows additional development to occur in and near existing settlements in exchange for protecting rural lands from development. Planners can use this tool to create large ecologically intact areas of natural habitat. The heavy black outlines in the diagram show the boundaries of the TDR sending area (at left) and the TDR receiving area (at right).

quality core and secondary habitat areas. For legal reasons, most TDR programs do not prohibit development in the sending area, although they may discourage it by reducing the allowed density of development. Given the essentially voluntary nature of most TDR programs, the successful programs are those that establish incentives to make it more profitable for landowners in the sending area to sell their development rights than to build on the property itself. To promote biological conservation goals, incentives could be offered on a "sliding scale" so that the most valuable tracts of habitat within the sending area are worth the greatest number of development credits if their owners participate in the TDR program. Even with good incentives in place, however, TDR cannot always be counted on to protect any particular parcel. Thus, if the study area contains unique or especially valuable conservation targets, it may be wise to supplement TDR with other land protection strategies, such as outright acquisition.

Sublandscape Scale (Cities, Towns, and Counties)

We define the sublandscape scale as groups of land uses and ecosystems within an area roughly several miles or kilometers across. Examples would include the entire jurisdiction of many North American cities, towns, and townships; portions of counties; and watersheds of third- or fourth-order streams. Whereas the

overall conservation vision should be established at the landscape scale so as to plan for large patches, persistent populations, and functioning ecosystem processes, the sublandscape scale is especially relevant to planners since this is the level at which many regulatory and administrative tools are implemented. Two important conservation goals for planners working at the sublandscape scale are (1) to implement the LCDP by directing land use at the local level,* and (2) to influence the sequence of land transformation (which areas are developed first). Four approaches for reaching these goals are discussed below.

Conventional Zoning

Conventional zoning is often referred to as *Euclidian zoning* after the landmark 1926 U.S. Supreme Court case *Village of Euclid (Ohio) v. Ambler Realty Co.*, which established its constitutionality as a permissible exercise of local governments' police power. This approach, which remains planners' principal tool for directing development, involves dividing a jurisdiction into various zoning districts, each of which allows different types of land uses and has different requirements for lot dimensions and other development characteristics. The districts are usually delineated on a zoning map, and the accompanying requirements for each district are described in a zoning ordinance, code, or bylaw.

From the standpoint of ecology, Euclidian zoning can be either positive or negative. The fundamental concept of zoning a jurisdiction based on the suitability of the land in each area to accommodate different human uses is basically the same approach used in ecologically based planning. The problem is that zoning maps are often based less on the land's *environmental* suitability than on its *economic* or *transportation* suitability, historical precedent, or even political expediency. For example, countless jurisdictions have chosen to locate their industrial districts along rivers and in floodplains, creating a host of ecological problems as well as planning dilemmas for communities whose residents now want public access to their waterfronts.

A deeper problem of relying exclusively on Euclidian zoning to protect biodiversity and ecological integrity is the great difficulty of designating zones that exclude development completely. This restriction in the use of zoning is based on federal laws and judicial precedent in the United States and, to a lesser extent, in Canada that generally prohibit the government from "taking" property without

* The idealized planning process presented here involves close cooperation between different levels of government to prepare a broad-brush LCDP at the county, regional, or state level (with local input) and then implement it primarily at the municipal or county level (or both). In reality, this level of cooperation does not always exist—either for logistical reasons (e.g., not enough planning resources) or for political ones—but this should not derail the basic approach advocated here. For example, in the absence of an LCDP prepared at the county, regional, or state level, local governments can still place their planning and zoning activities in a larger ecological framework by looking outside the boundaries of their jurisdictions.

An overlay zone is a mapped zoning designation that stipulates an additional layer of land use control beyond the base zoning district. For example, a lot adjacent to a river might be in a residential base zone as well as a floodplain protection overlay zone. The base zone may limit land uses on the lot to single-family houses, while the overlay zone may require any new buildings to have a finished-floor elevation above the 100-year flood elevation.

The term *environmental protection zoning* refers to zoning districts, overally zones*, and other regulations that prohibit or restrict development in environmental sensitive areas. These designations can apply to a wide range of areas, including wetlands, floodplains, stream corridors, steep slopes, ridges, mesas, and plant and wildlife habitat. They can be enacted at all jurisdictional levels, from federal wetland protection laws in the United States to various provisions at the state/provincial, county, and local levels. Biodiversity-based environmental protection zones in the sense that they do not ordinarily delineate on a map those areas that are subject to land use restrictions; instead, the jurisdictional areas are defined according to the habitat needs of different species.

Environmental Protection Zoning

- The most important lands could be targeted for protection through outright purchase or conservation easements.
 - The next most important lands could be the target of environmental protection laws (see below) or could be protected using transfer of development rights.
 - Protection laws (see below) or could be protected using transfer of development rights.
 - The remaining greenprint lands should be considered during site planning.
 - Various site planning guidelines (see below) can encourage or require developers to steer clear of these areas as they design and develop individual sites.

One alternative to this depressing sequence is to prepare a *greenprint*—a map identifying potential conservation areas, such as wetlands, steep slopes, rare species habitats, and rare ecological communities—very early in the development of a community. Then, as growth arrives, it can be directed to less sensitive lands. Over time, as the community nears buildout, a protected, interconnected corridor network will take shape within the matrix of developed lands. This approach is very similar to the landscape conservation and development plan discussed above, but it applies at a finer scale. Whereas the LCP identifies large patches for core habitat, secondary habitat, production lands, and urban areas, the community greenprint recognizes that within each of these large patches is a cluster-scaled mosaic of ecologically valuable as well as less valuable areas. With the greenprint in hand as guidance, the planner can work to protect sensitive lands through a variety of means. For example:

As we discussed in Chapters 3 and 6, development guided by conventional zoning controls usually proceeds along an unfortunate trajectory. First, natural habitats for many native species, and the result is a heavily degraded local environment.

“Greenprinting”

In Chapter 6, we pointed out that large lot zoning almost always hurts native species and ecosystems because it spreads human influence over a wide area, removing much of the land's ecological value without using it efficiently for human purposes. A much better approach is to aggregate most human settlement in designated areas, ideally those areas of lower ecological value or uniqueness, using such tools as transfer of development rights and conservation subdivisions (see below). Nevertheless, because lot zoning is and probably will continue to be widely used, we explore in Box 10-1 what types of conservation values may be provided on lots of different sizes. We also offer suggestions for how low-density housing development might be modified to reduce its negative impact on native biodiversity.

Aware of this legal constraint, many planners have turned to *large lot zoning* to discourage development at least as far as density in areas that are less environmentally suitable for development. Residential or "rural residential" zoning districts in suburban and exurban areas commonly require a minimum lot size of two, three, or five acres (0.8, 1.2, or 2 ha) for a single-family house, and in some rural parts of the U.S. Midwest and West, the minimum lot size is ten, twenty, or even forty acres (4, or 16 ha). Large lot zoning has certainly resulted in lower housing densities, but it is no longer much of an impediment to development because of a number of sociological factors—including the growing willingness to commute long distances, the rise of telecommuting, the growing numbers of retirees and second-home owners, and an increased emphasis on quality of life to choose a house—plenty of people want to live on large lots in more remote locations.

all economic uses of a piece of property has been deemed an illegal "regulatory duly compensating the owner. In the United States, zoning denies essentially

Box 10-1**Large Lot Zoning: Can It Provide Any Ecological Benefits?**

While it is clear that large lot zoning is ecologically detrimental in many respects, it is worth exploring whether, and under what circumstances, this zoning approach may offer some ecological value. Like many questions in ecology, the answer to the question "Can large lot zoning provide any ecological benefits?" is "It depends." However, we can develop some useful guidelines by answering this question in the context of several different conservation goals.

Conservation Issue	Considerations	Guidance on Minimum Lot Size and Other Design Factors*
Can large lots provide habitat for generalist animal species?	Some human-tolerant mammals and birds can survive in suburban areas. Gardens that contain native plant species offer insect and bird habitat.	Lots of 1 acre (0.4 ha) or less may suffice as long as vegetation is properly managed (see pages 161–64).
Can large lots protect stream water quality and natural hydrology?	Physical and biological stream characteristics begin to degrade when impervious surface in the watershed reaches 7 to 10 percent. ³	House lots of at least 2 acres (0.8 ha) usually result in impervious coverage below 10 percent. To prevent pollution, site design should protect riparian buffers, minimize turfgrass, and properly manage stormwater.
Can large lots provide habitat for reptiles, amphibians, and mammals with small home ranges?	Some such species can survive on patches of 1.5 acres (0.6 ha) as long as adequate water features are included.	Lots of at least 4 acres (about 2 ha) where water features are protected may offer habitat value. Corridors to nearby native habitats may improve this value.
Can large lots protect native plant communities and rare animals with small home ranges?	Viable populations of many plants can persist on 12-acre (5 ha) habitat patches buffered at least 100 feet (30 m) from buildings, yards, and roads to minimize edge effects. Such patches can also sustain populations of some small animals.	Houses centered in lots of 15 acres (6 ha) each will have habitat patches of 12 acres between them. Corridors to adjacent habitats may improve long-term population viability.
Can large lots protect populations of forest interior birds, human-sensitive grassland birds, and mid-sized carnivores?	Patches of 60 acres (25 ha) can support many area-sensitive bird species as well as predators such as foxes. However, human influences may still limit biodiversity. ⁴	Houses centered in lots of 50 acres (20 ha) each will have habitat patches of 60 acres between them. Corridors to adjacent habitats may improve long-term population viability.

Can large lots protect populations of large-bodied, wide-ranging mammals?

Animals such as black bears and elk are very sensitive to road density.

Large lot zoning is not suitable to protect these species because of their very large space requirements and high sensitivity to human activities.

In each instance cited above, the desired conservation goal can be met only if the house is situated appropriately on the lot such that the most sensitive habitats are located as far from human influences as possible. The guidelines in the table also assume that the entire lot will remain natural habitat with the exception of the house, a small yard, and a driveway. The size of the disturbance patch created by development on a lot is very important; if small, it may not introduce all of the disturbance processes into the nearby natural areas.

In addition, the table assumes that the entire landscape in question is to be developed with house lots of the indicated size. Even with very large lots, this pattern of evenly distributed, low-density development (and the roads needed to access it) will perforate and fragment the landscape to a large degree, significantly curtailing its overall habitat value. However, habitat provided on large lots may become more valuable to native species if it is linked into a larger complex of habitat in nearby conservation areas. These considerations indicate that large lot zoning can offer much more ecological value if it is used in combination with such other conservation tools as land acquisition, riparian zone protection, and low-impact development (see below). Using this approach, zones of low-density housing development can be used to buffer core habitat areas from more intensive human land uses. They may also offer limited habitat value in their own right.

In what is essentially a twist on large lot zoning, some jurisdictions have established protective zones for farming, forestry, or habitat lands that combine large minimum lot sizes with other policies to discourage subdivision and development of the land. For example, a model Agriculture and Forest Protection District proposed for Minnesota would allow no more than one division of land (i.e., one subdivided lot) for each forty acres. Newly-created house lots would need to be between one and two acres (0.4 and 0.8 ha), thus preserving the remaining thirty-eight to thirty-nine acres (15 to 16 ha) for farm/forestry uses. Subdivided farm/forest parcels would need to be at least twenty-five acres (10 ha), thus retaining the "large patch" benefits of these rural land uses.⁵ Similar approaches can be used to steer development away from sensitive habitats.

NOTES

*Information is derived from the following sources except where noted: Lowell W. Adams and Louise E. Dove, *Wildlife Reserves and Corridors in the Urban Environment* (Columbia, MD: National Institute for Urban Wildlife, 1989) and references cited therein; several papers in Lowell W. Adams and Daniel L. Leedy, eds., *Wildlife Conservation in Metropolitan Environments* (Columbia, MD: National Institute for Urban Wildlife, 1991); Eric A. Odell, David M. Theobald, and Richard L. Knight, "Incorporating Ecology into Land Use Planning: The Songbirds' Case for Clustered Development," *Journal of the American Planning Association* 69, no. 1 (2003): 72–82.

For the third, fourth, and fifth rows of the table (4-acre, 15-acre, and 50-acre lots), minimum lot size is determined by calculating the smallest square lot that, when tiled in sequence with other equally sized square lots, will contain a circular habitat patch of the indicated size plus a 100-foot (30 m) buffer in the undeveloped space between houses on adjacent lots, assuming that the houses are situated in the center of the lot and that each house plus its surrounding structures extends 50 feet (15 m) from the center of its lot. It should be noted that smaller lots could contain a habitat patch of the indicated size if houses were situated closer to the edge of the lot.

³C. L. Arnold and C. J. Gibbons, "Impervious Surface: The Emergence of a Key Urban Environmental Indicator," *Journal of the American Planning Association* 62 (1996): 243–58.

⁴Jeremy D. Maestas, Richard L. Knight, and Wendell C. Gilbert, "Biodiversity across a Rural Land Use Gradient," *Journal of American Planning Association* 17, no. 5 (2003): 1425–34.

⁵Minnesota Environmental Quality Board and Biko Associates Inc., *From Policy to Reality: Model Ordinances for Sustainable Development* (2000), <http://server.admin.state.mn.us/resource.html?id=1927> (accessed August 2, 2003).

- Development phases* has historically been used as a tool to prevent rapid bursts of growth that exceed a community's ability to provide the new roads, schools, and public safety services demanded by a new development. One form of development phasing consists of growth rate limitations that either (1) cap the number of building permits that may be issued in a jurisdiction within a given time frame or (2) require developments over a certain size to be phased in over several years. Under the first approach, for example, a municipality might set a worldwide maximum of 200 building permits per year, while under the second approach, it might limit the construction of a major new housing development

Development Phasing

Recently, many jurisdictions have adopted or recommended riparian protection laws based on these scientific findings. For example, Massachusetts re-tection laws require setbacks outside urban districts development within 200 feet (60 m) of perennial streams outside urban cores; Clark County, Washington, requires county review and habitat protection measures for projects proposed within 150 to 250 feet (46 to 76 m) of streams, depending on their size; and the Connecticut Department of Environmental Protection recommends a 100-foot (30 m) buffer along perennial streams and a 50-foot (15 m) buffer along intermittent streams.⁸

These factors suggest that the width of naturally vegetated riparian corridors should be determined case by case. However, this approach is not practical for most planners and designers and may also run a risk of legal requirements for regularity consistency. A more realistic approach is to define a default width requirement, which may then be reduced, if necessary, based on site-specific requirements, especially where conditions within the buffer or the watershed are less than optimal.

All of these functions are enhanced by dense vegetation, a well-developed soil or gemonic layer, silty or loamy soils (as opposed to sandy or clayish soils), minimal human disturbance, and flat topography. Riparian corridors lacking these characteristics will need to be wider to provide the same filtration function. Similarly, a wider corridor is needed when the surrounding watershed is steep, experiences high rainfall or many heavy storms, or has high rates of erosion or pollution from urban land uses, agriculture, or clear-cutting.

- Vegetation and leaf litter slow the flow of water and sediment from uplands to the stream.
 - Under certain conditions, bacteria consume biologically available nitrogen and release it to the atmosphere as nitrogen gas.

of listed species as identified through field studies, vegetation mapping, and similar

Environmental protection zoning has undoubtedly contributed to the protection of native species and habitats, even when this was not its primary intended purpose. For example, floodplain protection zones are usually established to prevent property damage but often have the effect of preserving a riparian buffer that filters pollutants, shades the stream, and provides a habitat corridor for species movement. In addition to environmental protection zoning that offers "incidental" habitat benefits, many jurisdictions have enacted specific habitat protection ordinances. For example, the town of Franklin, Massachusetts, has taken steps to protect identified habitat for deer, fox, coyote, ground-nesting birds, reptiles, amphibians, and state-listed threatened and endangered species. The town may require developers of land within the district to set aside wildlife corridors that are contiguous with corridors on adjacent sites, cluster development to minimize its overall footprint, avoid the use of wildlife-restrictive fence, and retain indigenous vegetation.

Environmental protection zoning has undoubtedly contributed to the protection of native species and habitats, even when this was not its primary intended purpose. For example, floodplain protection zones are usually established to prevent property damage but often have the effect of preserving a riparian buffer that filters pollutants, shades the stream, and provides a habitat corridor for species movement. In addition to environmental protection zoning that offers "incidental" habitat benefits, many jurisdictions have enacted specific habitat ordinances. For example, the town of Falmouth, Massachusetts, has taken steps to protect identified habitat for deer, fox, coyote, ground-nesting birds, reptiles, amphibians, and state-listed threatened and endangered species. The town may require developers of land within the district to set aside wildlife corridors that are contiguous with corridors on adjacent sites, cluster development to minimize its overall footprint, avoid the use of wildlife-restrictive fencing, and retain indigenous vegetation.

In Chapter 6, we presented a range of human threats to freshwater ecosystems and their biodiversity. Addressing these threats requires two sets of steps. First, watershedwide efforts are needed to limit the effects of human land uses, such as chemical, thermal, and nutrient pollution, as well as erosion (these approaches are discussed in the next section, "Habitat Scale"). Second, adequate buffers of natural vegetation must be maintained alongside water bodies. Both steps are critical: without watershed management, pollutants will quickly exceed the capacity of buffers to absorb them (and may pollute the groundwater); without vegetated buffers, such critical functions as bank stabilization and stream shading will be lost.

Planners often ask how wide a riparian buffer of natural vegetation must be for it to perform the desired ecological functions. Again, this depends on the function in question. Even a narrow vegetation corridor (e.g., twenty-five feet, or eight meters, wide) is valuable for shading the stream, contributing detritus, stabilizing the bank, and providing habitat for animals that live in or near the bank. However, other functions—such as trapping sediment and pollutants, absorbing excess nutrients, and providing riparian habitat and movement corridors for many vertebrate species—generally require greater width. Riparian廊带

- Fine particles and organic matter in the soil absorb pollutants.
- Plants incorporate nutrients into their tissues.

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to no more than 25 percent of the total units per year. Another type of development phasing links development approvals to infrastructure availability through such techniques as concurrency requirements or adequate facilities ordinances. These provisions require that infrastructure such as roads and sewers be in place before development can proceed at a given location. If a developer wants to build in a location that lacks adequate infrastructure, he can either fund the infrastructure himself or wait until publicly funded infrastructure is extended to the site.

By thinking spatially, planners can use development phasing as a tool to affect the sequence and speed at which native habitat is transformed to built land. In Chapter 6, we presented a land transformation sequence that retains large patches of natural vegetation on the landscape for as long possible while weaving corridors and small reserves into the built portion of the landscape (see Figure 6-10). Fortunately, this land transformation model is consistent with many of the teachings of good planning practice, which recommend aggregating built areas in order to attain efficiencies of land use, transportation, and infrastructure while enhancing the social and economic synergies of tight-knit communities. A development phasing policy to promote ecologically optimal land transformation might include the following provisions:

- An adequate facilities ordinance matched with an infrastructure plan that targets new roads, water and sewer lines, and public facilities to less ecologically sensitive areas aggregated together and in close proximity to preexisting settlements
- A growth rate limitation ordinance that establishes a maximum citywide (or countywide) annual building permit cap as well as an ecologically based "point system" that gives preference in the issuance of the permits to projects that (1) are close to existing settled or degraded lands versus large blocks of native habitat, (2) have low impacts related to habitat destruction and fragmentation, and (3) provide ecological benefits, such as habitat restoration or improved watershed management

Habitat Scale (Sites and Lots)

The habitat scale offers the widest range of challenges and opportunities for designers such as engineers and landscape architects. This, too, is where developers can have the greatest influence. While often maligned as environmental villains, developers have a critical role to play in protecting ecological integrity. First, they control the land (subject to regulatory constraints) and, with it, the power to protect, conserve, and restore. The rise of flexible development regulations makes it increasingly possible to do so while still profiting handsomely. Perhaps even more importantly, developers and their allies in the marketing in-

dustry strongly influence consumer preference for real estate products. Conventional wisdom in real estate marketing is often at odds with ecological design—for example, the notion that home buyers prefer large private yards to protected open space, or exotic landscaping to native species. But these "preferences" are in large part a creation of marketing efforts to sell the product that developers have historically built.

Ecologically minded developers can redirect this marketing energy to promote more harmonious forms of development. This point is illustrated by the example of Village Homes, a green development in Davis, California, that includes a natural vegetation stormwater management system, edible landscaping, and other eco-innovations. When the first units were placed on the market in the late 1970s, some realtors refused to show them since they did not fit the standard model; now, Village Homes is among the most desirable addresses in Davis, and its units sell faster and for more money than comparable houses in other developments.⁹

For designers and developers, three principles may help with planning a site in a way that protects its conservation values while providing access to nature for future human occupants. Throughout this book, we have emphasized the importance of understanding and designing land with regard to its ecological context. Thus, a first principle for ecologically based site-scale planning involves designing each small piece of the landscape in a way that essentially implements larger-scale ecological plans, such as the LCDP and the sublandscape-scale greenprint. Zoning regulations may mandate consistency with these plans, and designers can use them to help understand the potential contribution of their site to landscape-scale conservation goals.

Second, when opportunities exist to integrate small patches of nature into site plans, designers should consider not only how humans can benefit from such amenities as walking trails or bird-watching areas but also how these small patches can simultaneously advance conservation goals, such as protecting unique microhabitats or stepping stones. As we discussed in Chapter 8, there are few parts of the landscape that we can afford to dismiss as ecologically unimportant; even urban parks can provide ecological benefits if properly designed.

Third, recalling the concept of ecological health discussed in Chapter 6, site designs should strive to use land in such a way that it does not become permanently degraded or impair the integrity of off-site ecosystems through such impacts as pollution or fragmentation. The following three specific design techniques illustrate how these principles can be applied at the habitat scale.*

* Although all of these techniques are applied at the scale of sites or lots, they tend to be enabled or mandated by laws enacted at the municipal or county level.

- How the site layout can maximize interior habitat versus edge site given its size and limitations
- What species or communities should be targeted for conservation on the space and how levels of each one can be optimized through layout of the natural areas
- What flows (people, animals, wind, chemicals) will influence the open space and how they do not really solve the problem of sprawl—

logical maps or data layers that show land cover, rare species habitats, and protected land in the surrounding area. Other important factors to consider include

Reducing Development's Footprint

Limiting the amount of land occupied by human activities is probably the best way to protect ecological values at the habitat scale. Techniques such as conservation subdivision design (also known as cluster development or open space residential development) set aside undeveloped land by essentially shifting development away from the site to another. Instead of spreading houses evenly across the site using "cookie cutter" geometry, developers may group them together on smaller lots, ideally on the least environmentally sensitive lands. The remainder of the site is then reserved as undeveloped land, typically parks. This arrangement prevents its future development (see Color Plate 10). Planned unit developments (PUDs) take a similar approach, except that the development is usually a mixture of housing and nonhousing uses and is built at a higher density. Finally, many jurisdictions require a portion of any development site or newly created lot to be reserved as "open space." While this type of requirement is common, in many cases the open space is merely lawn or planted non-native shrubs that offer little habitat value.

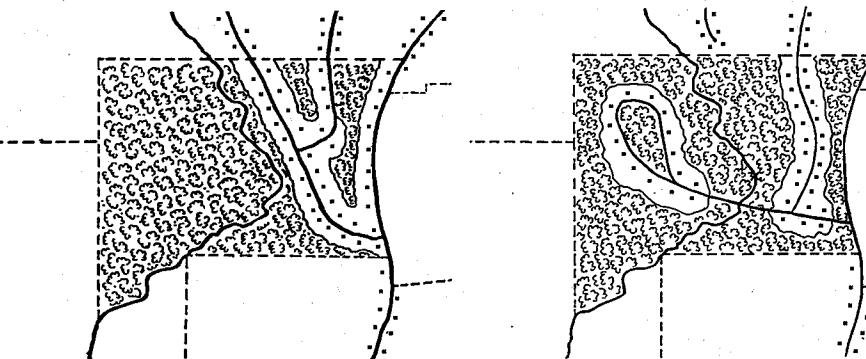


Figure 10-4. When planning a conservation subdivision, aesthetic and ecological

Figure 10-4. When planning a conservation subdivision, aesthetic and ecological goals sometimes conflict. An aesthetic focus might lead to design (a), where the goals of houses closer to the road. Both site plans contain the same number of houses.



Figure 10-5. Requirements for wide roads, shallow grades, and long sight distances translate into the need to destroy and regrade large amounts of native habitat.

low-density development spilling into rural areas. In landscape ecology terms, clustering aggregates land uses at the site scale, but not at the landscape scale, where it matters most. This critique points to a few recommendations for planners. First, open space protected through clustering should fit into a citywide or countywide greenprint or similar ecological framework to help conserve ecological values at a larger scale. Second, when considering whether to require a minimum percentage of a development site to remain as open space, planners should weigh the value of the open space against the possible ecological benefits of more concentrated development (which might ultimately reduce the demand for additional land conversion). For example, large front, side, and rear lot setbacks usually provide little ecological benefit (although they may offer some human benefit) and can contribute to sprawl. Finally, for a very large site—perhaps a few thousand acres or more—clustering and PUDs can be an effective technique for securing natural habitats with large-patch benefits.

Ecologically Based Site Development Practices

Whether one is building a conservation subdivision, a city park, or a shopping center, the ecological outcome of the project can be vastly improved by incorporating sensitive design features (see Figures 10-5 and 10-6). Unfortunately, most of these features are at odds with conventional development practices. Table 10-1 compares conventional and ecologically sensitive approaches to several aspects of site design. Many of the sensitive development practices can actually yield substantial savings to developers by reducing expensive site preparation



Figure 10-6. This photo illustrates some of the principles of sensitive site design, including the use of narrower roads and the retention of native vegetation. The development shown in the photo contains 33 dwelling units on 64 acres (an overall density of about one unit per two acres), yet 86% of the site was retained as undeveloped woodlands and meadow.

costs, such as earth moving and roadway construction. Planners can facilitate the use of these practices by ensuring that local development regulations do not preclude such approaches (by, for example, mandating excessively wide roads). Some jurisdictions also have regulations that proactively encourage or require the use of sensitive development practices.

Environmental Review

In many jurisdictions, state/provincial and local environmental review is required for major development projects. On the local level, environmental review may be part of subdivision review or site plan review or may be required in conjunction with the issuance of a special permit (a conditional use permit). These reviews almost always consider engineering factors, such as stormwater runoff and grading, but ecological considerations are often lacking. Even where the law requires an evaluation of the project's habitat or wildlife impacts, the analysis provided is often cursory, biased, or ill informed. By not requiring (or not enforcing the requirement for) meaningful ecological assessment as part of local environmental review, planners miss out on a prime opportunity to promote conservation within development projects. An ecological assessment requirement based on the considerations in this book might call for the information shown in Box 10-2.

Regarding the last point in Box 10-2, one way to view an ecosystem is as a package of values and services: species diversity, genetic diversity, nutrient cycling, hydrological functioning, and so on. A worthy goal for land use proposals is to retain—if not increase—the total value of this package through a strategy of “minimize, mitigate, compensate.” First, minimize losses by avoiding impacts

³James C. MacCormack, *The River Book* (Hartford: Connecticut Department of Environmental Protection, 1998).

⁴Troy W. Adams, *Urban Wildlife Habitats* (Minneapolis: University of Minnesota Press, 1994).

Conventional landscape areas are a major contributor to the spread of invasive species.

Landscape

Use native plant species primarily or exclusively in landscapes and ornamental gardens. Proprieties are landscaped with native plants. Dominate by native plants. Increase habitat diversity.

Commerical and residential

Use native plant species primarily or exclusively in landscapes and ornamental gardens. Proprieties are landscaped with native plants. Dominate by native plants. Increase habitat diversity.

Streams that allow stormwater flooding

Stream flow will reduce flooding. Systems that infiltrate into the ground (as opposed to running off through gutters or pipes) increase base stream flow while reducing flooding.

Stormwater Management

Design stormwater management systems that mimic natural processes. More information is available from the Low Impact Development Center (<http://www.lid-stormwater.net>) and the U.S. Environmental Protection Agency's Office of Water (<http://www.epa.gov/lid>), with additional resources at <http://www.lid-stormwater.net>.

Research on the mortality and habitat fragmentation effects of roads indicate that wider roads, all increase detrimental effects on native fauna. Wide roads, paved roads (versus unpaved) and higher vehicle speeds, and roads indicate that wider roads, in many cases, require more traffic and increase standards of safety.

Road Design

Wide roads based on traffic patterns for road width, grade, turning radii, sight distance, and impervious surface area. Have vegetation and increase distances for shallow grades. Reduce shoulder widths, and turnings radii, and long sight distances to speed.

Landscape

In urban and suburban areas, the amount of impervious surfaces face in a watershed is usually the most important factor influencing the health of fresh-water ecosystems. Excess impervious surface areas, particularly roads, offer several opportunities to reduce flooding. Systems that infiltrate into the ground (as opposed to running off through gutters or pipes) increase base stream flow while reducing flooding.

Much of the site is clear-cut to facilitate earth moving disrupts the soil profile and kills much of the soil biota, soil-capping topsoil for later re-sprouting worsens these effects. Even if native vegetation is repopulated in the amount of clearing and graded areas (and it rarely is), it may take decades to approximate a natural community.

Land Clearing and Grading

Earth moving disrupts the soil profile, especially during rainy periods. Stabilize bare slopes with mulch or plants at any time, especially during times that from urban land.³

Construction-Period Impacts

Prior to construction, determine a no-disturb zone on a plan and in large patches and piles of bare earth, which are very susceptible to erosion.

Construction

Earth moving disrupts the soil profile and kills much of the soil biota, soil-capping topsoil for later re-sprouting worsens these effects. Even if native vegetation is repopulated in the amount of clearing and graded areas (and it rarely is), it may take decades to approximate a natural community.

Impervious Surface

Clusters of subdivisions require developments to build wide roads and over-lay parking lots. Developers to build less roadway than conventional designs. Clusters of subdivisions require developments to use paved roads and the use of park-and-ride facilities.

Stormwater Management

Design stormwater management systems that infiltrate into the ground (as opposed to running off through gutters or pipes) increase base stream flow while reducing flooding.

Landfill

Landfill usage creates impermeable pavements can be used for overflow parking areas. Taller pavements can be used for water infiltration. Excess impervious surface areas, particularly roads, offer several opportunities to reduce flooding. Systems that infiltrate into the ground (as opposed to running off through gutters or pipes) increase base stream flow while reducing flooding.

Wetlands

Wetlands are often better at trapping and neutralizing pollutants in stormwater and can be more aesthetically pleasing.

Agreement with Landscape

Integrating stormwater management and infiltration, and nutrient cycling systems that infiltrate into the ground (as opposed to running off through gutters or pipes) increase base stream flow while reducing flooding.

Detention/Retention Pond

A centralized discharge point or real ones by treating and infiltration systems that mimic natural habitats in stormwater and can be more aesthetically pleasing.

Soil Erosion

Soil erosion is a natural process that occurs in every landscape. Soil erosion is often caused by runoff from steep slopes, cut-and-fill slopes, and often occurs on gullies and roads to minimize the need for cut and fill.

Soil Health

On sites with topographic relief, extensive reggrading of soil horizons to minimize soil runoff for later re-sprouting worsens these effects. Even if native vegetation is repopulated in the amount of clearing and graded areas (and it rarely is), it may take decades to approximate a natural community.

Soil Compaction

Soil compaction is a natural process that occurs in every landscape. Soil compaction is often caused by runoff from steep slopes, cut-and-fill slopes, and often occurs on gullies and roads to minimize the need for cut and fill.

Soil Loss

Soil loss is a natural process that occurs in every landscape. Soil loss is often caused by runoff from steep slopes, cut-and-fill slopes, and often occurs on gullies and roads to minimize soil runoff for later re-sprouting worsens these effects. Even if native vegetation is repopulated in the amount of clearing and graded areas (and it rarely is), it may take decades to approximate a natural community.

Soil Pollution

Soil pollution is a natural process that occurs in every landscape. Soil pollution is often caused by runoff from steep slopes, cut-and-fill slopes, and often occurs on gullies and roads to minimize soil runoff for later re-sprouting worsens these effects. Even if native vegetation is repopulated in the amount of clearing and graded areas (and it rarely is), it may take decades to approximate a natural community.

Table 10-1.



Box 10-2 Sample Requirements for Ecological Analysis as Part of Environmental Review

- A map showing the site's land cover or vegetation types, ecological attributes such as unique habitats or rare species occurrences, and surrounding context. This requirement creates an information loop in which site-specific studies (conducted by developers and others) are incorporated into citywide or countywide maps, which are in turn consulted to help plan for future site-specific projects.
- A map and calculation of the acreage in each habitat type on the site both before and after development. This "accounting" approach makes clear both the degree of the habitat impacts and the extent to which the development will affect high-quality versus lower-quality habitats.
- Identification of any rare or threatened species on the site; the habitats, conditions, and resources they require, and the measures proposed to avoid impacts to these species.
- Discussion of how the proposed development will affect off-site ecosystems—for example, by diminishing or enhancing habitat connectivity or by changing the rate of nutrient runoff.
- Discussion of proposals to mitigate losses to the site's ecological integrity through ecological restoration, land protection, or other efforts.

in the first place. Next, mitigate any losses through designed solutions, such as replanted vegetation or constructed wetlands for treating polluted runoff. Finally, compensate for loss in one value with improvement in another—for example, by restoring an area of degraded land. To be sure, various "eco-assets" are not interchangeable or fully separable from one another. Yet, if a site is to be modified for human use, tradeoffs must inevitably be made. Although it is difficult to truly replicate a natural habitat, a "no net loss" approach is a major improvement over conventional practice that often fails to identify, much less address, the loss of ecological values.

Up to this point in the chapter, we have focused on approaches to protecting native species and ecosystems in developed or developing landscapes. We now turn again to the second of the major themes of this book: safeguarding human communities from natural hazards.

Protecting Human Safety in the Ecological Context

In 1993, flood waters ripped through the midwestern United States, breaching more than a 1,000 levees, damaging 70,000 buildings, and killing fifty people.¹²



Figure 10-7. Land in Chesterfield, Missouri, that was under ten feet (3 m) of water during the floods of 1993 is now the site of 7 million square feet (650,000 square m) of new commercial space.

Near the confluence of the Mississippi and Missouri rivers in Chesterfield, Missouri, the Smoke House market, a local landmark identifiable by the giant pig on its sign, wallowed in more than ten feet (3 m) of muddy water. Luckily, at the time, the market had few close neighbors; much of the surrounding land was farm fields. Ten years later, this floodplain is home to the largest strip retail center in the United States—part of 7 million square feet (650,000 square m) of new commercial development here (see Figure 10-7). In pursuit of tax revenue and jobs, local and state officials not only allowed extensive development in the Missouri River floodplain but also used public funds to subsidize a bigger levee and a new highway interchange to make this development possible. Nor is this an isolated example: at least ten major development projects are under way within a short drive of Chesterfield, many of them publicly subsidized. These projects are slated to urbanize 14,000 acres (5,600 ha) of agricultural floodplain, most of which was underwater in 1993.¹³ While new levees offer some protection to these developments (at least until the next massive flood hits), they will also worsen flooding in other areas and raise the overall level of the rivers, reducing the effectiveness of all downstream levees.

Thirty miles away in Arnold, Missouri, the community responded to the 1993 floods in a very different way, purchasing 85 residences, 2 businesses, and 143 mobile home pads in flood-prone areas. Two years later, when another

