States and many parts of Canada, although actual flood zones are prone to change over time as a result of changing conditions in the watershed—especially increased development. Nevertheless, the existence of these maps makes it easy for planners to regulate development in flood zones by adopting overlay zoning designations that correspond to the federal or provincial flood maps. Within these zones, development can be either prohibited outright or required to be elevated above the maximum expected flood height. Some jurisdictions also require the provision of compensatory flood storage (e.g., constructed wetlands) to make up for any development that does occur in a floodplain.

This chapter has highlighted several planning tools and design techniques that can help land use professional create ecologically compatible developments, communities, and entire landscapes. The purpose here was not to present an exhaustive list of all such tools but, rather, to give some specific examples of how planners, designers, and developers can apply an understanding of ecological processes to their work. The final chapter of the book is an interactive planning and design exercise that offers the reader an opportunity to practice doing just this.

# 11

# Principles in Practice

*Gestalt* is a German word meaning "a unified whole . . . that cannot be derived from the summation of its component parts."[1] This word could describe the challenge facing planners and designers who seek to incorporate the lessons of ecology into their work. As we hope this book has indicated, ecologically based planning cannot be reduced to a recipe: there are few definitive answers and many uncertainties; solutions must be site specific yet context sensitive; and planners and designers must balance ecological factors against a plan's other, often competing, objectives. From designers of the land, the world demands integrated, ecologically based solutions.

For planners in the mid-twentieth century, the term *gestalt* connoted the practice of classifying land and deriving solutions from intuitive "gut feelings." This "gestalt method" of planning, which relies heavily on individual judgment, has largely been replaced by more empirical planning processes, in which factual data, public input, and a clear decision-making methodology ideally lead to more rational planning solutions.[2] This more systematic approach is essential for ecologically based planning: because so many ecological factors are relevant to planning and development activities, it is important to be clear about which of these factors are being addressed, how, and why. Intuition and intelligent synthesis are still important, but they follow and build upon ecological analysis. Therefore, let us begin by reviewing the key ecological lessons of this book (as shown in Box 11-1) before moving on to the planning exercise.

**Box 11-1**
**What We Can Learn by Listening to Ecology**

- Ecosystems usually behave according to certain general patterns, but chance plays a large role, too. Ecological communities and ecosystems are exceedingly complex, and our understanding of them is incomplete.
- The context and history of a site or study area play critical roles in determining its ecological form and function.
- Native species and ecosystems are important to protect for several reasons. They provide valuable, if not irreplaceable, ecosystem services and other economic benefits, and they offer humans aesthetic and spiritual nourishment.
- Long-term ecological integrity depends on the sum of four factors: the integrity of the physical environment, the integrity of native biota, the size and configuration of habitats within the landscape, and the context of the landscape.
- Planning must proceed based on the best ecological knowledge available at the time, recognizing that it may be a combination of well-known facts and working hypotheses.
- To ensure human health, safety, and welfare, planners and developers must know their ecological neighborhood—both biotic and abiotic.
- Nature reserves and open spaces can serve many different purposes for humans as well as native species. People should be clear about their goals before they plan or design these areas.
- Many planning and design techniques currently in practice—and others waiting to be developed and perfected—can help planners and designers apply the lessons of ecology to their work.

The planning exercise is divided into two parts corresponding to two different scales: (1) the site scale, at which developers, engineers, landscape architects, and development review officials typically work, and (2) the municipal or county scale, at which many planners work. The exercise is set in a hypothetical county in the southern Appalachian region of the southeastern United States. Although the places depicted in the exercise do not actually exist (and any similarities to a real site, town, or county are purely accidental), the details of the species and ecosystems profiled are accurate. The exercise incorporates a multitude of real ecological planning issues that currently face communities throughout North America: a sprawling suburban metropolis, development at the gateway to a recreational area, an expanding road network threatening to fragment natural ecosystems, agricultural production adjacent to sensitive waterways, and a patchwork of managed and unmanaged forests in public and private ownership. As you work through the exercise, think about the similarities between this hypothetical landscape and the one where you reside.



## Part 1: Residential Development at the Site Scale

### *The Situation*

Your firm has been hired to design a new residential development on a 128-acre (52 ha) site in the western foothills of the Jigsaw Mountains.* The developer (your client) envisions the project as providing a mix of single-family and small-scale multifamily housing in a bucolic setting close to the recreational amenities of the nearby national forest. He hopes to market the units to commuters from the nearby metropolis (about twenty miles or thirty kilometers, to the west), early retirees, or even second-home owners who want to "get away from it all" in a peaceful location.

Having just finished reading this book, you want to begin applying the lessons of ecologically based design to your work. As the lead designer on the project, you explain the basic principles of this approach to your client. You emphasize the importance of safeguarding the development's future inhabitants from natural hazards and also point out that effort spent at the outset to protect natural resources on the site could shorten the project's permitting timeline, given the county's recent emphasis on resource protection as spelled out in its new comprehensive plan. In addition, you explain to your client the ways in which ecologically sensitive development practices can reduce construction costs. These arguments make sense to the developer, and he likes the idea of doing the right thing ecologically. He also sees a promising new marketing angle for his development if he can depict it as "at one with nature."

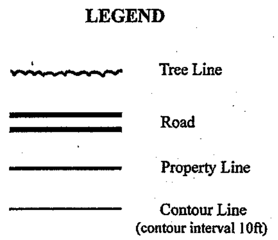
### *Part 1A: Asking the Right Questions*

At the start of the job, you are given a typical existing conditions plan prepared by a surveyor and showing the property boundaries, roads, and contour lines (see Figure 11-1). Although development plans are often prepared based primarily on this minimal amount of information about the site, clearly more must be known to inform ecologically based design. What questions would you need to ask before planning the site? *Please take a few minutes and write these questions down before proceeding to the next step of the exercise.*

### *Solution to Part 1A*

Ecological due diligence requires you to look well beyond the boundaries of the site, as well as forward and backward in time, to anticipate the natural processes of disturbance and succession affecting the site. Doing so will help fulfill

* If the "hat" you wear in real life is that of a developer, planning or zoning board member, development review official, or citizen, working through this exercise from the perspective of a designer will give you a better idea of what you should expect from a good ecologically based site plan.



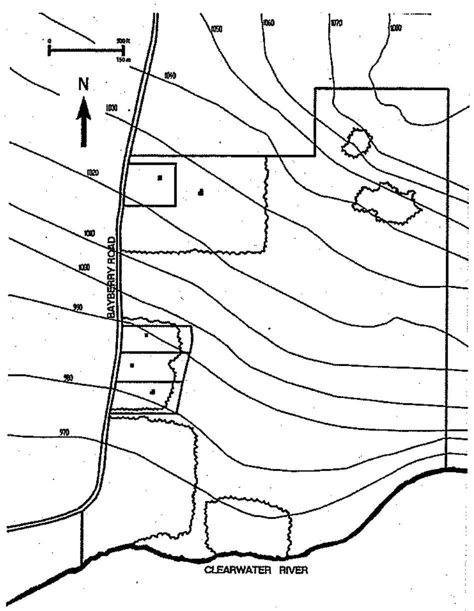




**Figure 11-1.** *Existing conditions plan.* This plan is similar to an existing conditions plan that a surveyor might prepare at the start of the development process. It includes property boundaries, roads, and contour lines—but no ecological information. What other information would you need to know about this site before proceeding with ecologically based design?

one of your primary responsibilities as a site planner: to safeguard the health, safety, and welfare of the site's future human inhabitants in relation to their ecological context. In addition, to protect and restore native species and habitats, you will need to obtain information on the site's biological diversity, its ecology, and its conservation status, which should be depicted in map form whenever appropriate. (Sources and approaches for gathering such information are discussed in Chapters 2 and 7 and in Appendix B.)

Asking and answering the following questions will provide a good basis to proceed with ecologically based design. *The brief answers to these questions provided below and shown on the site ecology map (Color Plate 11) and the ecological context map (Color Plate 12) should be used to inform the second part of the site planning exercise.*

*What disturbance processes affect the site?*

Answering this question requires looking beyond the site's boundaries and also forward and backward in time. You learn that forest fires regularly occur in the national forest and the private timber lands to the north and east of the site. Some areas are managed with prescribed burning of underbrush to enhance wildlife habitat or timber production, while other areas have dangerously high fuel loads as a result of decades of fire suppression by humans. You also infer from seeing many downed trees during your site walk that soil instability and windthrow of large trees is a common occurrence on the steeper parts of the site. In the spirit of due diligence, you consider other disturbance processes, such as flooding and hurricanes, but find that these processes are unlikely to occur on the site.



*What ecosystems are present?*

This question can be answered by using aerial photographs or satellite images combined with field surveys to identify the ecosystems on the site. On this site, the riparian zone includes an agricultural ecosystem (farm fields plus hedgerows) as well as a mature bottomland hardwood forest. The northeastern half of the site is a young oak-pine forest that was clear-cut about twenty years ago. Within this forest matrix is an outcropping of limestone where a distinct glade ecosystem has formed, harboring a diverse community of grasses, wildflowers, and animals adapted to live in hotter, drier conditions and in thin, rocky soils. The perennial stream creates a fifth distinct ecosystem at the edge of the site (see Color Plate 11).

*What important native species are present, including rare, keystone, umbrella, and dominant species? For these species, are the local populations viable or not? Are they isolated, part of a larger population, or part of a metapopulation?*

You hire an ecologist to help answer this question, who identifies several important species on the site. As it turns out, the population of the federally listed endangered Indiana bat (*Myotis sodalis*), which hibernates in the cave within the state forest just south of the site, also requires nearby riparian and hillside forest for roosting and foraging. The bat roosts in dead and dying trees where the bark has begun to peel away from the trunk—trees that are typically found in mature hardwood forests such as the one on the site.[3] The hardwood forest is also home to several species of Plethodontid salamanders, lungless amphibians that breathe through their skin. The Plethodontids also require mature forest with some moist areas and woody debris. The limestone glade harbors several rare flowering plants and mosses that live only in this unique environment. Finally, the stream at the southern edge of the site—like most intact stream ecosystems in the Southeast—harbors a great diversity of mollusks and fish, many of them endemic to a relatively small region. As heavily managed landscapes, the farmland and the oak-pine forest provide habitat for many generalist species that are found throughout the county but no species of particular interest for biodiversity conservation. (It is beyond the scope of this planning exercise to answer the population questions, but in a real planning project, this would be an important next step.)

*What is the site's ecological context in space and time?*
Key aspects of context include disturbance and succession, adjacent land uses, protected areas, landscape connectivity, and abiotic flows, such as water and nutrients. We have already discussed fire, soil instability, and windthrow as important physical disturbances within the site's forest ecosystems. However, biological agents also cause disturbance. A variety of insect and fungal infestations—including the southern pine beetle, gypsy moth, and anthracnose fungus—have affected large areas of nearby forest and might at some time spread to the site. Successional changes in the forests of this region generally follow the patterns described in Chapter 4. Following a clear-cut or major natural disturbance, drier south-facing slopes such as those on the site would tend to sprout various shade-intolerant deciduous species as well as pines, such as shortleaf pine and loblolly pine. Absent human or natural disturbances, such as fire, herbicide spraying, or thinning to promote stands of pure pine, the forest would tend to mature into an oak-pine forest, such as that found on the eastern half of the site. In moister areas, such as the southern portion of the site, succession leads toward an oak-hickory forest.

Other important aspects of the site's context are shown in Color Plate 12. This map indicates that the site is contiguous with large patches of undeveloped land to the north, east, and south, although some of these lands are heavily managed for timber harvesting. To the west is a patchwork landscape of forest, agriculture, and encroaching suburban development. Flows of silt and herbicides from upstream logging practices sometimes degrade water quality in the stream as it passes the site, while agrichemicals flowing into the stream from the site and nearby ones to the west influence water quality farther downstream.

*What is the current condition of the ecosystems at the site?*
At least four factors should be considered when answering this question: invasive species, missing species, chemical pollution and nutrient loading, and fragmentation. In terms of invasive species, kudzu vine is a problem in the hardwood forest, while planted shrubs—such as multiflora rose and bush honeysuckles—have spread from the farm's hedgerows into the surrounding woods. The most important missing species in the forest ecosystems are top predators, such as the gray and red wolves that once lived here. In their absence, populations of white-tailed deer and other herbivores have proliferated, affecting species composition in the forests and even threatening the survival of some herbaceous woodland plants.

Turning to chemical pollution and nutrient loading, you learn that such land use practices as logging and herbicide applications for forestry occasionally contribute silt and pollutants to the stream as it passes the site but that, overall, the stream ecosystem is in fairly good condition. Acid rain is an additional pollution threat—in this case, one that originates in cities and at smokestacks hundreds of miles or kilometers to the west. Finally, the effect of fragmentation on the ecosystem's condition must be considered. On the one hand, the site is contiguous with large areas of undeveloped forest to the east; on the other hand, much of this forest is actively logged, which reduces its value as core interior habitat.



*How are human activities likely to change or influence the site's ecology in the future?*
To answer this question, you must look beyond the site to consider both local influences (such as growth and development patterns) and regional and global influences (such as global climate change). On a local level, you examine the county's zoning map, review growth trends and projections in the county, and compare a current land use map with a historical one from twenty years ago. This information reveals that suburban and exurban growth are beginning to spread eastward toward the site, that agricultural land is gradually being converted to either forest or developed land uses, and that some protected land exists north and directly south of the site but none to the west. Scientific models predict that global climate change over the next century may make the southeastern United States considerably warmer, with average temperatures rising by 5°F to 9°F (3°C to 5°C) and the summertime heat index (a measure of heat discomfort that includes temperature and humidity) increasing by at least 10°F (6°C) and as much as 25°F (14°C). The models disagree about whether the Southeast will become wetter or drier but agree that heavy rains are likely to occur more frequently. One model predicts that drier conditions in the Southeast could change the predominant vegetative cover from forest to savanna.[4]

*What might the site have looked like in earlier times, and what are the opportunities for restoration?*
Remnant patches of old-growth vegetation nearby as well as ecological studies can provide a window through which to observe past ecosystems. Prior to the 1800s, forests blanketed the area, with hardwoods (including the now almost defunct American chestnut) being the dominant vegetation type. Regular disturbances were caused not only by natural events but also by Native Americans' use of fire. Over time, the forests on the site, if undisturbed, would acquire old-growth characteristics, such as numerous old trees, snags (standing dead trees), and a diverse forest floor community. There may also be opportunities to restore the connectivity of the local forests.

*What other human factors affect how this site can or should be developed?* Obviously, designers must not neglect those human factors that are normally considered when planning for development, such as zoning, transportation access, water and wastewater infrastructure, public facilities and services, and market considerations. However, since there are already many good planning texts that cover these topics (and since they are a standard part of designers' educational training), we will not discuss them here, except as they relate to this ecologically based planning exercise.

### *Part 1B: Preparing the Plan*

Now that you have a basic understanding of the site's ecological form, function, and context, you can proceed with preparing an ecologically based site plan. As mentioned above, the developer wants to build a residential development offering a variety of housing types in a country setting that will appeal to commuters, early retirees, and possibly second-home owners. The zoning for the site offers two different development options:

1. A conventional "rural residential" layout that allows single-family houses on 50,000 square foot (1.15-acre or 0.46 ha) lots, and
2. A Planned Residential Development option that allows the same total number of units as the first option, but in a mix of single-family and/or multi-family dwellings (up to four units per building) built on lots as small as 10,000 sq. ft. Under this second option, the development must provide open space as well as community or recreational amenities.

Given these zoning options, your client's wishes, and your knowledge about the site's ecology, how would you plan this site for development? Try sketching out a site plan showing the location of buildings, roads, and undeveloped areas. (To do so, you might want to use tracing paper or an enlarged photocopy of the existing conditions plan or the site ecology map.) Beyond the information shown on your site plan, what other considerations should go into the planning of this development?

### *Solution to Part 1B*

Three different site planning approaches are illustrated in Figure 11-2, Color Plate 13, and Color Plate 14, respectively. The conventional subdivision plan in Figure 11-2 is designed in accordance the first zoning option (single-family houses on 50,000 square foot lots). This design ignores most of the principles discussed in this book, and will result in an environment that is poorer for humans and native species. For example, although the oak/pine forest to the north and east of the site is fire-prone, the plan provides no fire buffer, thus threatening the safety and property of future inhabitants. In addition, despite the site's



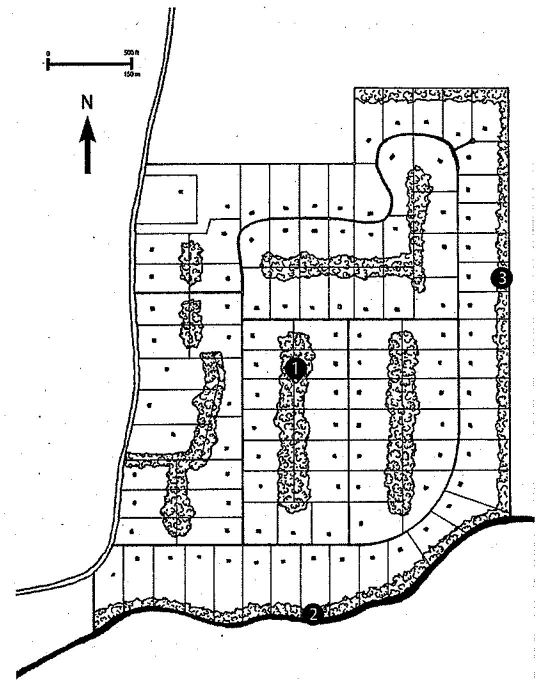



**Figure 11-2.** *Conventional subdivision plan.* This plan illustrates how development might proceed under the "rural residential" zoning option, absent any attempt to implement the concepts of ecologically based planning presented in this book. As is typical in conventional subdivisions, the entire site has been divided into individual house lots, and any residual patches of native vegetation (1) are so small that they offer little habitat value. Even though local laws mandate a fifty-foot (15 m) riparian buffer (2), this buffer may not be wide enough to provide a viable habitat corridor or filter out pollutants before they reach the stream. Residents may also be at risk from wildfire, because the houses on the east (3) abut an expanse of oak-pine forest, yet no protective buffering has been provided. Finally, this development provides no natural areas for its residents to use.

scenic, natural context, the plan provides no place for future residents to enjoy nature.

From an ecological standpoint, this plan's greatest drawback is its almost complete conversion of native habitat to houses, roads, and lawns. As a result, most native species associated with the glade, hardwood forest, and oak/pine forest habitats will disappear. The loss of mature hardwood forest on the site may even threaten the survival of the bat population that roosts nearby. Although a few small residual patches of trees are shown on the plan, these will probably support only generalist species that can survive in close proximity to humans.

The other two designs—the "rural cluster" plan shown in Color Plate 13 and the "village cluster" layout illustrated in Color Plate 14—both follow the second zoning option (single- and multi-family housing on small lots surrounded by open space). These plans both incorporate three elements for sound ecologically based planning for this site:

1. *Choosing a development pattern that does not take up too much space:* The Planned Residential Development (PRD) zoning option is far more conducive to ecologically based design than the conventional rural residential approach shown in Figure 11-2. Whereas the conventional design blankets the entire site with individual house lots and roads, the PRD option allows development to be concentrated on the most environmentally suitable portions of the site while setting aside undeveloped land for native species and ecosystems. Designers seeking to harmonize development with the natural environment (and planners trying to encourage such development) should make use of flexible zoning tools such as PRDs, conservation subdivisions (cluster developments), and transfer of development rights.
2. *Protecting human health, safety, and welfare in relation to the ecological context:* The greatest natural threat to this development will be forest fire, which is a regular occurrence in the surrounding oak/pine and pine plantation forests. To protect human lives and property, therefore, both of the ecologically based site plans buffer the dwellings from the surrounding oak/pine forests by design features such as community gardens, roads, a sports field, and a "town green." A buffer is less important to the south because the native oak/hickory forest is less fire-prone.
3. *Protecting the site's important species, habitats, and ecosystems:* As discussed above, the portions of the site that are most important for the protection of biodiversity include the limestone glade in the northeast (which sustains an assemblage of rare plant species), the hardwood forest near the stream (which provides food and shelter for the Indiana bat and the Plethodontid salamanders), and the stream itself (which contains rare mollusks and fishes). To safeguard these ecosystems, development on the site should steer clear of the important terrestrial habitats as well as a buffer area along the stream. In addition, land use patterns should minimize the potential for silt, chemicals, or untreated runoff to enter the stream.

Within these three basic parameters, there are many good ways to lay out the roads, houses, and open space on the site, two of which are shown in Color Plate 13 and Color Plate 14. From an ecological standpoint, the rural cluster plan (Color Plate 13) has several advantages. First, it maintains a wide stream buffer of at least 600 feet (180 m), which is ample to filter surface runoff before it reaches the stream, provide a wildlife movement corridor containing interior forest habitat, and create some distance between the houses and the nearby state forest, which is home to bear and coyote.

Second, it proposes retiring the farm fields adjacent to the stream and restoring them to native hardwood forest. These fields are now the only "missing link" in a continuous corridor of riparian forest to the east and west of the site. (Also, retiring these fields will reduce fertilizer and pesticide pollution to the stream.) Third, the plan preserves a wide forested corridor between the stream and the uplands to the northeast of the site, which will help provide connectivity between forest patches even if some of the surrounding lands are developed or converted to low-habitat-value pine plantations in the future.

Finally, the plan retains some of the existing agricultural land on the site, while also introducing community gardens where residents can grow fruits and vegetables. As discussed in Chapter 8, local food production is an important aspect of sustainability; the site plan therefore seeks to balance the protection of native habitat and the protection of productive agricultural land.

The village cluster plan (Color Plate 14) clusters the development even more tightly and concentrates it on the previously disturbed agricultural lands. Compared to the rural cluster plan, it results in less habitat alteration and intrudes less into the contiguous block of forest habitat that extends eastward from the site. The higher density design results in more of a "neighborhood" feel, with many of the houses clustered around common open spaces. However, none of the dwellings is more than a two- or three-minute walk from the natural forest that has been preserved on the eastern two-thirds of the site.

Both the rural cluster and village cluster site plans raise some interesting restoration and management challenges. For example, in the rural cluster plan there are a few possible ways to restore the farmland in the southwest corner of the site to riparian forest. One solution is simply to abandon the farming activities and allow succession to run its course; at the other extreme, one could plant seedlings of desired tree species. Given cost constraints and the proximity of existing hardwood riparian forest ecosystems east and west of the restoration site, a relatively "hands-off" approach might be the most feasible. However, initial active management will be needed to make sure that invasive species do not take over and that the site is sufficiently stabilized so that topsoil does not erode into the stream.

As the designer, you may also need to work with the developer and local planning officials to design a long-term management framework for the conservation and agricultural lands on the site. Who will own these lands and determine how they are managed? Should a management plan be drafted now, as part of the planning process? Who will pay for managing the land and taking care of any problems that arise? What role (if any) will future residents of the development play in managing these lands? The discussion on land management in Chapter 9 addresses some of these questions.

## Part 2: Planning for Growth by Listening to Ecology

In Chapter 6, we suggested that the *landscape* is the most effective scale at which to plan for the conservation of biodiversity. A much smaller focus area is too small to consider important ecosystem processes and flows or to plan for the long-term viability of populations of many wide-ranging species. A larger focus area can sometimes help in understanding and protecting biodiversity but is inconsistent with how human land use decisions are usually made—at the local or county level—and thus may be less effective, unless the large-scale vision can be reflected in smaller-scale plans. The scale of a landscape is typically tens of miles or kilometers across or, in terms of human boundaries, roughly the size of a county, a few counties, or part of a state or province. Depending on the subdivision of local governments where you live, most planning may actually occur at the sublandscape scale (miles or kilometers across). This is consistent with the appropriate scale for biodiversity planning as long as the sublandscape scale plans are carefully situated within their landscape context.

From the preceding discussion, it is clear that municipal, county, and regional planners should be on the front lines of human efforts to conserve biodiversity. This part of the planning exercise offers a chance to apply the lessons of this book from the perspective of these planners. Since it is not practical to use a landscape-scale study area of hundreds or thousands of square miles or kilometers for the planning exercise, a smaller area of roughly fifty square miles (130 square km) is used. It may help to think of this scale in terms of the local government jurisdictions where you live. For example, a plan at this scale could be a comprehensive plan for a town, township, small city, or portion of a county or a region.

### *The Situation*

As a staff planner in a public-sector planning agency, you have been asked to prepare a land use plan for an area of roughly fifty square miles (130 square km, or 32,000 acres). The plan should reflect a long-term (twenty- to thirty-year) vision for the future and will serve as the basis for your jurisdiction's official zoning map as well as for decisions related to public facility and infrastructure investment, land and resource conservation, and other policies. Since the mission of your planning agency (as well as your professional responsibility as a planner)[5] includes the protection of natural resources, such as native species and habitats, you decide to prepare the plan using the ecological planning approach presented in this book.



### *Part 2A: Asking the Right Questions*

As you begin working on the plan, you have access to the various data sources that planners typically use—local and regional census data, state economic statistics, and various geographic data layers, including transportation networks, land use, rivers and streams, and tax maps (property boundary maps) available through your agency's geographic information system (GIS) department. What additional geographic data layers and other information would you need to prepare an ecologically based plan for the study area? What questions would you need to ask before preparing the plan? *Please write down these answers before proceeding to the next step.*

### *Solution to Part 2A*

One good way to depict ecological information at a municipal or county scale is to prepare a set of annotated maps that show basic environmental data plus text or graphic annotations that explain major ecological functions, processes, or flows. Depending on the complexity of the ecosystems in your study area and the amount and type of data available to you, this effort could consist of a dozen or more maps or as few as three. Below, we present what we consider to be the three indispensable maps and corresponding sets of questions to ask about your study area. *These questions, answers, and maps should be used to inform the second part of the community-scale portion of the planning exercise.*

1. LOCAL ECOLOGY.

This map and analysis describe the local vegetational communities and ecosystems, ecosystem processes, and species of conservation interest (see Color Plate 15). The base map should depict vegetational communities in as much detail as possible, as well as surface water features and major human corridors that fragment the landscape, such as roads. In addition, the map should identify the protection and management status of natural lands within the study area to help indicate their current and likely future ecological integrity. Thus, the local ecology map includes ecosystem delineations and functions as well as human delineations of the landscape. This map and the accompanying analysis should answer the following questions.

*What ecosystems and vegetational communities are present?*
The eight land cover categories shown in Color Plate 15 provide a first approximation of the different ecosystem types in the study area. The three forest

types—deciduous, mixed, and conifer—range from lightly to heavily managed. For example, most of the hardwood forest is lightly managed, with occasional use for timber harvesting, hunting, or recreation, while many of the evergreen forests are heavily managed commercial pine plantations. Each of the forest ecosystems contains an ever-changing mosaic of vegetational communities regulated by natural disturbance, human disturbance, and succession. There are also some small but distinct vegetational communities created by their soil or microclimate, such as riparian floodplain forests, limestone glades, and hillside seeps. These smaller ecosystems may not show up on a sub-landscape scale map but are still important to identify because they may be especially rich repositories of biodiversity. Human-dominated ecosystems in the study area include agricultural areas and developed land.

*What species of conservation interest are present?*
As discussed in Chapter 5, species of conservation interest are often rare species, keystone species, or umbrella species. Several rare species in this landscape are discussed on page 221, including the Indiana bat, Plethodontid salamanders, freshwater mollusks and fishes, and grasses and flowering plants within the limestone glades. Two umbrella species are worth noting. At the eastern edge of the study area and extending into the national forest beyond, the black bear (*Ursus americanus*) is considered an umbrella species because of its requirement for large and predominantly roadless habitat areas (generally more than 5,000 acres, or 2,000 hectares), a variety of forest types to meet seasonal foraging needs, and some late-successional forests with large snags and cavities for denning.[6] Brook trout (*Salvelinus fontinalis*), which live in the southern of the two rivers shown on the map, require cool, well-oxygenated streams with gravelly bottoms and a pool/riffle structure. Thus, they are not just an umbrella species for other sensitive freshwater species but also an indicator of overall watershed health. One keystone species (actually a group of species) in the hardwood and mixed forests are the oaks (*Quercus* species), which provide an important food source (acorns) for numerous bird and mammal species.

*For the species of conservation interest, are the local populations viable or not? Are they isolated, part of a larger population, or part of a metapopulation?*
Answers to these questions may not be readily available to planners or even to ecologists. Nevertheless, clues can be found by examining the distribution and abundance of species of conservation interest both within and outside the study area. For example, knowing from a field guide that Plethodontid salamanders require moist hardwood forest and disperse only tens of meters during their lifetimes, you could infer that the salamanders within your study area are divided into a number of subpopulations, each somewhat isolated from the others by the intervening matrix of unsuitable pine plantation or dry oak-pine forest. With additional information about the typical area of the salamanders' home range or population density, you may also be able to estimate which patches of hardwood forest are capable of sustaining viable populations of these amphibians in the long term. Similarly, knowing that the home range of black bears is roughly eleven to fifteen square miles (28 to 40 square km), you could infer that the bears found in the study area are part of a population whose range extends well into the national forest. Forest managers may be able to tell you whether the bear population is increasing, holding steady, or decreasing,

*What is the current condition of the ecosystems of this landscape?*
As discussed earlier in this chapter, some of the major factors affecting ecosystem condition include invasive species, missing species, chemical pollution and nutrient loading, and fragmentation. The amount and persistence of fragmentation are especially important to consider at the landscape and sublandscape scales when planning for future development and conservation. For example, the western part of the study area is beginning to be fragmented by essentially permanent developed land uses. While native vegetation in the central and eastern portions is fragmented by agriculture and pine plantations, these land uses are probably both less persistent and less incompatible with native ecosystems than urban development is. In addition, some of the former farms in the central portion of the study area have been abandoned and are beginning to revert to forest. Minimizing fragmentation by considering these and other factors should be an important aspect of the planning outcome.

*Where are the most important habitats in the study area?*
This question can be answered in a few different ways depending on the available data. The first choice is to delineate critical habitats based on preexisting data, if it is available (see Chapter 7 and Appendix B). If this is not possible, one could estimate the most important habitats based on information on the species of conservation interest (e.g., habitat requirements) plus landscape ecology principles. These considerations would lead you to conclude that the most important habitats in your study area include riparian forests and floodplains, limestone glades and other rare microhabitats, unmanaged or lightly managed forests contiguous with the protected areas, and hardwood forests within one mile of the Indiana bat roosting cave in the southern nature reserve. These areas are delineated as orange circles on Color Plate 15.

*How well protected is the study area's native biodiversity?*
Answering this question requires looking at the relationship between ecological boundaries and human boundaries. As shown on Color Plate 15, the study area

contains relatively little land that is protected from development, and some of it—the national forest—is not managed primarily for conservation. The two reserves that are managed for conservation do contain critical habitat, but other ecologically important lands in the study area are not protected. In addition to the protection status of these lands, other conservation opportunities and threats should be examined. For example, proposed roads, sewer extensions, or market pressures could all constitute conservation threats, while zoning laws or lack of market demand could provide some level of protection (albeit usually temporary or incomplete).

2. LANDSCAPE-SCALE ECOLOGY.

Looking beyond the boundaries of the study area to the landscape scale allows us to consider broader land patterns and flows as well as processes that occur over longer time frames. At this scale it is helpful to map the same base data suggested for the local scale—land use or land cover, surface water, roads, protected areas, and critical habitat areas—although this may be done at a coarser scale (see Color Plate 16). This analysis should also consider other factors from outside the study area that impinge on conservation and land use planning within the study area, as presented in the following questions.

*Are there critical habitat areas nearby? If so, are they linked to natural areas within the study area?*
As shown in Color Plate 16, several large natural areas are situated north, south, and east of the study area, which are currently linked to natural lands in the study area and have the potential to remain so in the future. These linkages appear important for maintaining black bear habitat as well as genetic flow between the population of Indiana bat in the study area and nearby populations just outside the area. In addition to linkages, such barriers as large rivers, highways, cities, or large monoculture farms in the surrounding landscape should be noted because these could negatively affect conservation efforts within the study area. Finally, it helps to examine the landscape context of the two major river corridors that traverse the study area: the river in the northern part of the study area has several dams and a major reservoir downstream of the study area, while the river in the southern part of the study area is free-flowing. This information might help prioritize riparian conservation efforts within the study area.

*What other outside human and natural forces are likely to impinge on the study area in the future?*
Relevant outside forces will vary from place to place but could include influences such as: (1) a major tree pest or disease in the next county or state that is likely to spread to the study area; (2) regional development pressures that are likely to affect the study area; (3) state/provincial or national policy decisions or major infrastructure projects such as road construction that may encourage new development; and (4) global climate change.*



3. LOCAL NATURAL HAZARDS.

To accomplish their mission of protecting human health, safety, and welfare, planners must document and guard against an array of natural hazards. This information can be mapped using a combination of preexisting data sets (e.g., 100-year floodplains as delineated on U.S. Federal Emergency Management Agency flood insurance rate maps in the United States or floodplains mapped through the Flood Damage Reduction Program in Canada) and estimates of areas most threatened by hazards such as fires, landslides, and violent storms. For hazards that have not yet been mapped, planners can create estimated hazard zone maps by using data layers on the factors that contribute to the hazard, such as land cover type, slopes, and soils. For example, you might know from past experience that landslides occur most often on soil type X in areas exceeding 30 percent slope, or that Ponderosa pine forests that have not burned within the past twenty years are most susceptible to destructive wildfires. Color Plate 17 is an example of a natural hazards map for the study area showing the areas most susceptible to four different hazards: flooding, wildfire, landslides, and large predators.

Again, these three maps and sets of questions provide what we consider to be a minimum level of information necessary to proceed with ecologically based planning. They are a supplement to—not a replacement for—traditional planning analysis.

## *Part 2B: Preparing the Plan*

The American Institute of Certified Planners' Code of Ethics and Professional Conduct states that "a planner must pay special attention to the interrelatedness of decisions." In other words, planners almost never plan for just a single objective. So it is with biological conservation, which must share space at the planner's table with economic development, affordable housing, efficient transportation, and myriad other goals. The political realities of property rights, local resistance to change, and the agendas of elected and appointed officials add another challenge, as any practicing planner can attest. They also impel planners to search for solutions that find common ground among these often competing objectives and stakeholders.

* In some regions, such as coastal or boreal areas, where there are generally agreed upon predictions of the effects of global climate change, this should be an important part of the analysis. In areas where the likely effects of climate change are less well established, your analysis might ask more generic questions, such as "if species need to migrate north to adapt to a warming climate, are there enough viable north-south corridors or stepping stones in or near the study area for these species to use?"

To make the planning exercise more realistic, let's add some basic parameters or assumptions about the other planning goals and constraints that must be incorporated into the plan:

1. The plan must accommodate a projected population increase in the study area from 12,000 at present to 18,000 in twenty years.
2. Community goals necessitate that the plan identify solutions to increase the amount of affordable housing and bring in new commerce and industry to provide jobs and property tax revenue.
3. Funds will be available from local and state sources to protect about 4 percent of the study area's land as open space over the next ten years.
4. Local voters and politicians generally oppose policies that are perceived as denying or sharply curtailing individual property rights.

Keeping in mind these parameters and the ecological information presented above, what would your land use plan look like? As you prepare your solution to this section of the planning exercise, focus on two aspects of the plan: (1) create a generalized future land use map showing areas designated for different types of conservation and development (to do this, you might want to use tracing paper or an enlarged photocopy of the local ecology map), and (2) formulate any additional policies that you think are necessary to guide future land use. *Please prepare the map and additional policies before proceeding to the solution.*

### *Solution to Part 2B*

As most planners know, many valid ways of solving a land use question often exist, each of which balances multiple considerations in a slightly different way. Thus, the solution presented below and in Color Plate 18 is intended not as the single "best" solution but as a good solution that illustrates many of the principles of ecologically based planning.

When creating a land use plan, the order in which different land uses are delineated can strongly influence the final planning outcome. Until recently, for example, planners have generally paid the most attention to where housing, commerce, and industry should be located; as a result, extensive areas of prime farm soils and biologically important river valleys have been paved over when less productive or environmentally sensitive sites might have done just as well or almost as well. Ecologically based planning operates according to a different paradigm that optimizes the fulfillment of human as well as ecological needs on the landscape by prioritizing the use of limited land resources. In other words, since conservation lands are some of the least interchangeable of the various competing land uses (i.e., a species can be conserved most easily in the places where it lives, and an ecosystem can be conserved only by protecting the land where it exists), it makes sense to select and designate these areas first. Similarly, prime farm soils should generally be reserved for agriculture, even though they may also be good building sites. Once these "fixed" land uses have been designated, the planner can then apportion the remaining land among such uses as housing, industry, recreation, and second-priority conservation and agricultural areas. Here are some of the considerations that were used in delineating these various land uses as shown on Color Plate 18:



- *Conservation areas.* The most critical conservation lands should receive the highest levels of protection (such as outright acquisition) and are shown in a medium green on Color Plate 18. These lands include the areas designated as "critical habitat" on Color Plate 15 and other lands of high biodiversity value, such as riparian forests, forest near the bat cave, and ridgetop forest in the central part of the study area. Small conservation areas are also designated in each of the two larger communities so that residents there will have easy access to nature areas. Finally, a stretch of floodplain just east of the northern of the two town centers was selected for conservation in order to preclude inappropriate floodplain development and help protect water quality in the downstream reservoir shown in Color Plate 16.

  Although land acquisition funds are limited (and, thus, only 4 percent of the study area is designated for acquisition), other land protection strategies, such as transfer of development rights (TDR), can be used to guide development away from biologically important areas. As discussed in Chapter 10, TDR allows landowners to transfer development rights from "sending areas," where development is not desired (shown in light green) to "receiving areas," which are well suited to accommodate development (shown in brown). Land is thus conserved through a real estate transaction without the need for publicly funded land acquisition and without denying property rights to landowners in the TDR sending area. As shown in Color Plate 18, TDR could be used to help conserve "buffer" lands around existing protected areas and to steer development away from environmentally sensitive ridgeline and headwater forests. The TDR sending area also includes two large blocks of prime farmland, where excellent agricultural soils (and flooding issues) make the land especially suitable for agriculture but unsuitable for development. Thus, in the parlance of the landscape conservation and development plan discussed in Chapter 10, TDR is used to protect secondary habitat areas and intensive production lands. The TDR sending and receiving areas are also delineated so as to aggregate natural lands, agricultural lands, and urban lands in order to reduce habitat fragmentation, maintain a "critical mass" of farms in certain areas, and attain the efficiencies inherent in tighter-knit development patterns.

- *Other rural lands.* These areas, shown in pale yellow on Color Plate 18, are also intended for secondary habitat and intensive production but represent lower priority examples of each than the lands designated for acquisition or as TDR sending areas. Accordingly, residential development is not actively discouraged in the other rural lands as it is in the TDR sending areas. Since these lands make up the largest part of the study area, effective policies to guide any development that occurs here are especially important. The minimum lot size for residential development is a key consideration and should be based on the factors shown in Box 10-1. The other rural lands would be an excellent location to allow and encourage conservation subdivision design and to implement a greenprinting approach. These policies could help reduce the footprint of new development and ensure that buildings and roads are placed on the least environmentally sensitive portions of the site. An areawide greenprint could also create secondary conservation corridors and additional buffers around the more highly protected conservation lands.
- *Targeted development areas.* Areas designated for future higher-density development are shown in brown on Color Plate 18. These are also the TDR receiving areas—places where a developer could build at higher density in exchange for purchasing the development rights from land in the TDR sending area (thereby protecting that land). As shown on the map, most of the areas designated for higher-density development are adjacent to settlements, which means that existing infrastructure, such as roads, sewage treatment facilities, and fire stations, can serve this development.

While there is obvious appeal to directing new development into and adjacent to existing settlements, this type of development may not satisfy all market niches. One of the reasons people move to the study area is to enjoy the natural setting, recreation opportunities, and proximity to the national forest. Thus, two large development tracts are designated on land that is currently rural but that does not contain critical conservation features. These areas could be developed with condominiums, a golf course, a resort, or another type of complex that would help the community meet its housing and economic goals by promoting development in suitable locations. Finally, it is worth noting that in an actual land use plan, the areas designated for future higher-density development would probably be further subdivided into different types of residential and commercial zones—a step that we omit here for the sake of simplicity.



To implement ecologically based planning, the map-based land use plan should be supplemented by additional policies to guide future development and conservation. Transportation and road construction policies are a critical but often-overlooked opportunity to meld ecological and human needs. Since roads fragment habitat and often bring with them new development (which further fragments habitat), an appropriate aspect of local transportation policy may be to designate certain areas to be roadless. A roadless policy would prevent public funds from being used in a way that actively promotes the fragmentation of important habitats. For example, building a north-south road over the ridge in the center part of the study area (in the vicinity of the 1 on the map) might improve circulation, but from what we know about the local ecology, this would be an especially bad place to build a road. Thus, the ridgeline in the central part of the study area and the TDR sending area in the southeast corner could be designated as locations ineligible to receive public funding for new road construction.

Several of the other ecologically based planning approaches discussed in Chapter 10 would also be appropriate for use in the study area. Environmental protection zoning in the form of overlay zones could be used to restrict development in some of the hazard areas shown on Color Plate 17, such as floodplains and erosion-prone steep slopes. Requirements for ecologically sensitive development practices and the use of native species in landscaping and site design would help reduce the negative effects of developed lands on native species. Finally, for fire-prone sections of the study area, policies could be established that safeguard new developments from wildfire through the use of fire buffers, less-combustible building materials, or other design features.