1

Humans Plan

"A man, a plan, a canal, Panama."

Palindrome describing the creation of the Panama Canal

"I returned, and saw under the sun, that the race is not to the swift, nor the battle to the strong, neither yet bread to the wise, nor yet riches to men of understanding, nor yet favor to men of skill; but time and chance happeneth to them all."

Ecclesiastes 9:11, *King James Bible*

Over the past few millennia, humans have spread to cover the globe. In the process, we have changed more of the earth, more profoundly, than any species before us. We have altered the face of the planet by building a canal between the Atlantic and Pacific oceans, reestablishing a connection that had not existed for more than 2 million years; by cutting vast forests at all latitudes; and by changing the global climate. As human communities grow, we shape nature. With our advanced technologies, however, we often forget that nature shapes us as well.

As we extend ourselves across the landscape, we plan. Sometimes our plans are explicit and carefully thought out documents, while other times they are implicit thoughts, such as, "If I create a farm here, it will be productive for several years," or "If we build a town here, it will be a safe place to live." Plans give us a secure feeling about the future and reinforce our sense that we can control the landscapes where we live. Drawings and carefully crafted words describe what a given site or region will look like if the plan goes into effect—but these plans can be misleading in two ways.

First, most plans focus primarily on the site or area for which they are planning. While they may consider roads and other aspects of human society outside the study area, they rarely consider ecological issues beyond the boundaries. A certain piece of terrain is either *in* the study area (and included in the plan) or *out* of the study area (and typically ignored). In fact, most plans show virtually nothing that is outside the planning area or site, as if it were an island floating in space (see Figure 1-1).

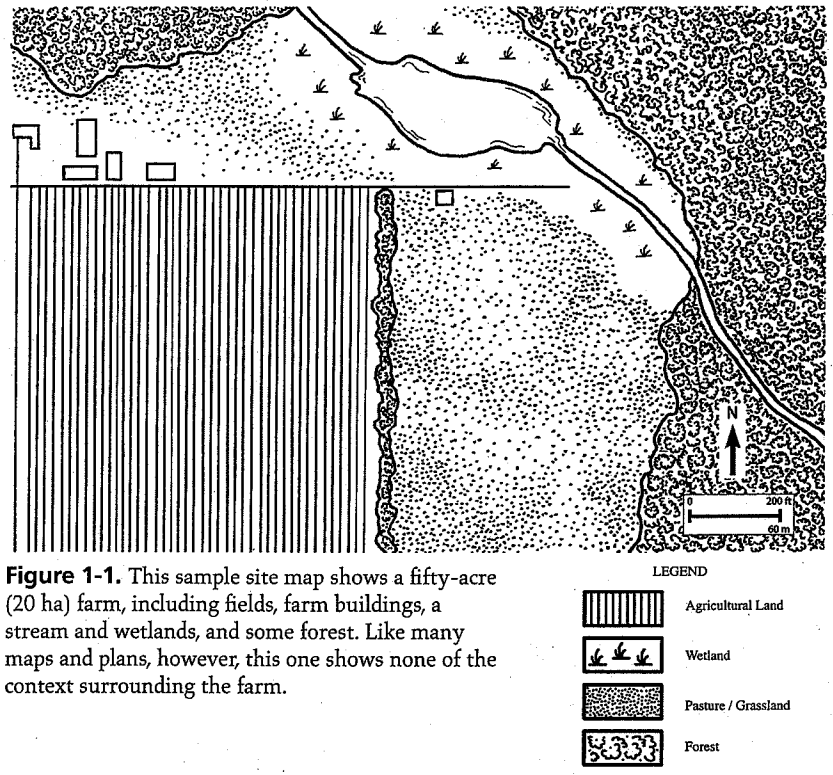


Figure 1-1. This sample site map shows a fifty-acre (20 ha) farm, including fields, farm buildings, a stream and wetlands, and some forest. Like many maps and plans, however, this one shows none of the context surrounding the farm.

Second, the planning and design process is often built on the assumption that human beings fully control the future of the study area. A carefully produced plan is a prediction that verges on being a contract: the plan tells residents of an area what their subdivision or community will become if the plan is followed. As a result, plans typically depict only one or, at most, a handful of future states. The science of ecology, on the other hand, recognizes that "time and chance happeneth to them all." Yes, we can plan and predict, but despite the seeming solidity of our plans' words and images, we cannot guarantee what the future of a site holds. The world of nature is full of chance events, and the mere passage of time brings its own changes as well.

The following two case studies explore the relationship between planning—a wholly human enterprise—and the workings of nature. As these examples illustrate, planners, designers, and developers would do well to consider the effects of time, chance ecological events, and ecological processes occurring beyond their planning area. By taking these factors into account, we can develop plans that

reap major benefits and avoid major problems. By ignoring these factors, we run the risk of costly or tragic consequences as nature runs its course.

New York City's Water

Beginning in the mid-nineteenth century, New York City developed one of the best municipal water supplies in the world in terms of quality, reliability, and innovative management.[1] Every day, the city's water system supplies 9 million people with 1.3 billion gallons of potable water.[2] The water comes from a system of nineteen reservoirs and lakes fed by a 1,969-square-mile (5,099 square km) *watershed* that extends more than 100 miles (160 km) north of the city. Perhaps most remarkable of all is that the foundations of this system were laid nearly two centuries ago, in 1835.[3] Today, almost all of New York's water still comes from upstate watersheds, and the main treatment that it receives is simply chlorination to kill the pathogens that are sometimes present at low levels.

In 1989, the U.S. Environmental Protection Agency (EPA) promulgated the Surface Water Treatment Rules, which grew out of the Safe Drinking Water Act of 1974.[4] Under these rules, New York City would have had to begin filtering its entire water supply for the first time. The filtration plants, according to the City, would have cost $6 to $8 billion to build and would have doubled the price of water for city residents. Instead, throughout the early and mid-1990s, the City and the EPA worked out an alternative to filtering the main water supply: the City would protect and improve water quality by helping towns in the watershed upgrade their sewage treatment facilities and by protecting thousands of acres of land in critical portions of the watershed. As of this writing, the City has purchased or obtained *conservation easements* on over 50,000 acres (20,000 ha) of land in the upstate watersheds.[5] The City alone has committed over $290 million for the land acquisition program, and city, state, and federal contributions to all facets of the watershed program total $1.4 billion.[6]

One of the most striking features of the agreement between the EPA and the city is the joint official recognition that nature can perform critical *ecosystem services* for humans. Instead of insisting on building giant filtration plants, the parties recognized that, through proper management, nature may be able to provide drinking water that is as safe as water provided by purely technological means. In addition to drinking water benefits, this watershed-based approach is helping protect rural landscapes just a couple of hours from New York City. Many farms will remain in business, and people are allowed to hike, fish, and hunt on much of the land that the city purchases.

In the early nineteenth century, the City of New York recognized that its water resources would become limiting, and the municipality looked beyond its

borders to create a remarkable water supply system. At the end of the twentieth century, the city again looked beyond its borders—and beyond the confines of human technology—to envision a future in which humans protect natural areas in ways that help both humans and countless nonhuman organisms living across the landscape. This example offers the following lessons:

- Sometimes we are better served by letting nature provide necessary services than by using technology to fulfill our needs. When we protect and maintain healthy *ecosystems*, humans can reap significant health and economic benefits.
- By setting aside parcels of nature for one purpose—in this case, to provide safe drinking water—both human and ecological communities may benefit in other ways. The watershed lands protect the rural character of dozens of communities as well as high-quality habitat for the region's native species.

While looking beyond the boundaries of a site can help identify the benefits and services that nature provides, taking a broad view can also help one avoid some of the problems that nature can bring, as the next case study illustrates.

Fire in Colorado

Several years ago, some friends of ours purchased a house in Pine, Colorado. This small community, nestled beside and within the Pike National Forest, has become a bedroom community for Denver as the capacity of the highways into the city has expanded. The mountain ridges surrounding Pine are covered with maturing pine forests that are not only lovely to look at but also contain a surprisingly intact *ecological community* that includes black bear, elk, mule deer, coyotes, and even mountain lions—all less than an hour's drive from Denver. This ecosystem offers aesthetic and recreational amenities that have undoubtedly contributed to Pine's recent popularity among home buyers.

This ecosystem, however, is not entirely benign. Although the setting of our friends' house appears quite suburban, with several houses visible nearby, mountain lions are enough of a danger that many children do not play outside at dusk or dawn. But the single most notable species in this ecosystem is not one of the large mammal species but rather the Ponderosa pines (*Pinus ponderosa*) that dominate the landscape. And the single most notable process in the ecosystem is fire.

Left alone, Ponderosa pine forests typically burn lightly and frequently, with ground fires removing underbrush while leaving mature trees intact. However, in areas where fires have long been suppressed and underbrush has been allowed to accumulate, as is the case throughout much of the American West, fires burn

heavily. As they engorge themselves on the dense growth left unpruned by the now-disrupted fire regime, they become massive, destructive crown fires capable of killing even the largest trees.

In June 2000, the Hi-Meadow Fire roared through the subdivisions and forests of Pine with impunity. The 10,800-acre (4,400 ha) fire destroyed fifty-eight structures, including several houses that could be seen from our friends' deck, but firefighters stopped the blaze thirty feet from their house (see Color Plate 1).[7] The fires around Pine offer several critical lessons:

- *Understand the ecological processes of the place you are planning or designing.* Developers creating new subdivisions in Ponderosa pine forests, and local planning commissions that approve these subdivisions, need to understand how the local ecosystems function. The same lesson applies to ecosystems across the continent.
- *Context is critically important.* What is outside the boundary of a site can add tremendous value—economic, ecological, recreational, or aesthetic—to the site, but it can also threaten health, safety, and property.
- *Always consider the array of possible futures for the land around a site.* This includes changes that may be brought about by humans, those that might occur naturally, and those that may occur through a combination of human and natural causes.
- *Plan with a measure of humility.* There are forces in nature that we may not be able to control.

The examples of New York City and Pine demonstrate that when we plan for the future, we need to look beyond the edges of our properties—which the planners of New York's water system certainly did, but which the designers of the subdivision in Pine did not do adequately.

Different Ways of Thinking about the Future

Planners, designers, ecologists, and conservationists all concern themselves with how specific landscapes will look and function in the future, and many of these professionals attempt to shape the future in different ways. But each profession approaches its work from a different background and with a different set of issues in mind, and each tends to view the world in a very different way (see Table 1-1). Developers who build houses in a wetland know that they may be penalized under the laws of humans and that some houses may end up with wet basements because of the laws of hydrology. Planners, in contrast, might be most concerned with how development in the wetland will affect the lives of humans, some of whom live far downstream from the wetland. Ecologists and conservationists

would be more likely to focus on the effects of such development on nonhuman organisms, many of which spend only a small part of their lives in the wetland.

Land use planners, designers, and developers usually work within unambiguous geographic boundaries and over relatively short time periods. In considering the future of a site, designers and developers generally assume that they can alter only land that is part of the development site and not neighboring parcels. Similarly, planners have jurisdiction only within the municipality, county, district, state, or province where they work and not in adjacent jurisdictions. Of course, many land use professionals *do* make an effort to consider the larger context. For example, planner Randall Arendt, in his book *Growing Greener*, suggests that designers create site context maps that extend 1,000 to 2,000 feet (300 to 600 m) beyond the boundaries of their parcels.[8] But even this amount of context, which exceeds common practice, might not reveal important ecological processes that could affect the site under consideration—such as the Hayman Fire in Colorado, which ran seventeen linear miles (27 km) on June 9, 2002, needing only four minutes to spread half a mile (0.8 km) at one point.

By contrast, ecologists considering a piece of land would be aware of natural influences that exist *outside* the site's formal boundaries: physical processes, such as fire and wind, as well as biological impacts, such as pest outbreaks and *invasive species*. They would also consider how the landscape looked in the past and what it might look like in the future absent human intervention.

Another important difference among the professions is the certainty with which each anticipates future events. The planning and development processes involve several contractual and quasi-contractual relationships, unlike the practice of ecology, which involves none. A developer usually contracts with lenders and designers, and sometimes with landowners or future tenants, to create a specific building program on a site. In turn, the developer and the local government also have a quasi contract: developers can build within the community as long as they follow its zoning laws as well as building codes and other applicable regulations. These zoning laws are also the result of an implied contract between the community's residents and its planners and other officials to establish and maintain the community as a safe, healthy place to live.

Nature, in contrast, is not subject to contracts. In fact, ecologists hardly ever attempt to predict the future with certainty, and they are aware that the general rules they propose often hold true only in broad terms over long periods of time. Ecologists often say that the first law of ecology is "It depends." In thinking about the future, ecologists discuss what *might* happen or, at the strongest, what will *probably* happen. Ecological systems are too complex and contain too many interacting variables to allow us to be certain about the ecological future. Ecologists

Table 1-1.

Different Viewpoints among Professional Disciplines

Ways of Viewing the Land	Designers and Developers	Planners	Ecologists and Conservationists
Predictability of Events	Events are relatively predictable; the future will be shaped by today's actions. Human systems, such as laws, property rights, and financial markets, provide a large measure of predictability.	Future events can generally be predicted from current human policies and activities, but these can interact in complex ways resulting in unexpected outcomes.	The future may hold surprises, as unexpected ecological events (and historical patterns) shape the landscape. The first law of ecology is "It depends."
Role of History	Assuming a clear title and lack of contamination, a site's history is relatively unimportant in determining how it may be used.	We should learn from history (and, in some cases, try to preserve its legacy), but we are free to create our own future.	The ecological history of a site may constrain its future in important ways.
Boundaries	Sites have clear boundaries demarcated by property lines.	Jurisdictions and districts have clear boundaries, although those at different levels may overlap or coincide.	Boundaries are unclear; effects extend across human-drawn and natural boundaries; different organisms experience very different boundaries.

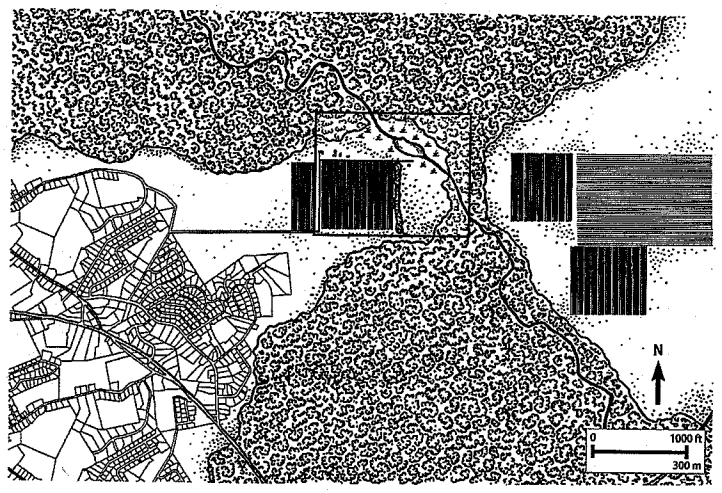
tell us that we need to know the history of a site *and* the natural patterns of ecological change for that landscape *and* the context of the site simply to understand the range of possibilities that might occur in the future. In this regard, ecological systems are much like the weather: at one level, they are deterministic and controlled by fundamental laws of physics and chemistry, yet they are too complex to allow humans to know every aspect of their workings. Instead, we infer and predict using a combination of observational and theoretical knowledge, improving our predictive power as time passes. With this level of ecological uncertainty, can a planner create an implied contract to keep members of the public safe within their ecological context?

Although it is impossible to capture all the nuances and complexities of these professions in such a brief space, the large differences in assumptions and ap-

proaches stand out clearly. There is nothing in the world of ecology and conservation—other than extinction—that is as clearly defined as a property boundary or a tax bill. But the certainty and finality of extinction drives much of the work of conservationists, for while a boundary or tax bill may be changed, extinction cannot.

Planning with Context in Mind

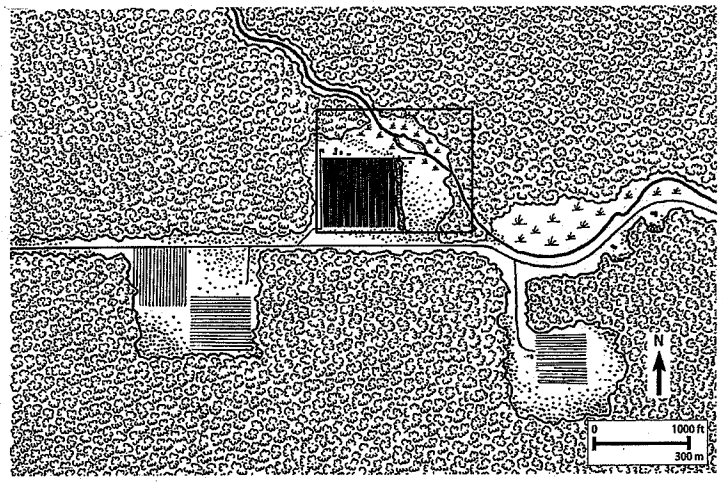
To appreciate the importance of considering a site's ecological context in space and time, let us return to Figure 1-1, in which we saw a hypothetical site as it exists today. The site contains fifty acres (20 ha), of which about thirty acres are currently farmland and fields, ten are forest, seven consist of a pond, stream, and wetland, and three are roads and buildings. Typically, developers and designers working on a site such as this will have considered the site's human context, such as the location of roads, schools, and nearby land uses, as well as such factors as zoning, property values, and the marketability of different development options. But what about the site's ecological context? Consider a series of three maps, each of which shows the site in a different ecological context (see Figure 1-2). These different contexts have profound implications for the site itself.



A

Figure 1-2. These three maps show three different hypothetical contexts for the site depicted in Figure 1-1. Each context might lead planners and developers to value the fifty-acre (20 ha) site in the middle very differently.

B



C

For example:

- *Are the forest patches on the eastern and northern sides of the site contiguous with additional forest, or are they isolated patches?* The forests are contiguous with larger forests in all three situations (Figures 1-2a, b, and c). In Figure 1-2a, the site's eastern forest plays a critical role in a habitat corridor connecting two large forested areas. In Figure 1-2b, the site's eastern forest is part of a buffer between agricultural lands and a lake/wetland system. The site's northern forest is part of a small forest patch that might be an

important habitat "stepping stone" for birds crossing the landscape or that might be a relatively unimportant piece of habitat. In Figure 1-2c, the site's forests are just tiny parts of a large forest, although the eastern patch helps to buffer the stream that flows through the property. Cutting the northern patch of forest on the site would probably have little ecological effect.

- *What kind of forest does the site contain?* Is it a mature woodland or new growth on recently abandoned farmland? What tree species live there, and do threats exist to the health of any of the tree species (for example, are hemlocks being killed by insect pests, as in the eastern United States, or are tanoaks and other species dying off, as in California)? We cannot determine the age, condition, or ecological functioning of the forest from these maps alone, but an ecologist or forester would be able to answer these questions after examining the site.
- *What are the dominant processes in the forest—for example, fire, wind, or landslides?* This is an especially critical question, as the previously discussed example of Pine makes clear. In Figure 1-2c, the site is surrounded by forest; if this forest is fire-prone (as the Ponderosa pine forests of Colorado are), the site is at risk of fire approaching from any direction.
- *What role do the site's agricultural lands play in the larger landscape?* In Figure 1-2a, the site's fields are among the only ones near a growing suburban area. Farming may be an important part of the region's history, and this particular farm may function as an important reminder of that past. In Figure 1-2b, this farm is just one of several in the region, and there may be no special reason to preserve it as agricultural land.

All of these questions are germane to planning the site for development or conservation or both. For example, if fire is common in the landscape, designers must find a way to protect any proposed development on this site from fire hazards. If the site adjoins conservation land or if its forest is one of only a few natural outposts in an agricultural landscape, it may offer important conservation values. On the other hand, if the site borders a metropolis, it may be the next logical place for orderly growth. Box 1-1 identifies some key ecological issues for land use professionals to consider when planning a site.

The simple example shown in these maps illustrates a major theme of this book: context always matters, and without understanding this context it is impossible to create a plan that adequately safeguards humans and natural ecosystems. As landscape ecologist Richard Forman wrote in the preface to his book *Land Mosaics:* "It is simply inept or poor-quality work to consider [land] as isolated from its surroundings. . . . Moreover, because we know this is wrong . . . the practice is unethical."[9]

Box 1-1
Understanding the Ecological Context of Your Study Area

In developing a plan, certain aspects of a site, area, or region are critical to keep in mind:

- *Past processes*—both human and natural—that have brought the site to its current condition
- *Future processes*—both human and natural—that are likely to or might affect the site in the future
- *Ecological details of the site*, including the dominant plant and animal species that will affect the future of the site
- *Areas surrounding the site*—built, agricultural, and natural—where many of the processes that will affect the site in the future will begin (and where many of the processes that begin within the site will have their greatest effects)

Safeguarding Human Communities: Ecological Due Diligence

When people move to a new neighborhood, they usually consider not only the condition and amenities of the house or apartment they are thinking of buying or renting, but also whether the neighborhood is safe, convenient, and welcoming. Planners, designers, and developers all attempt to create neighborhoods and living spaces that are attractive in these respects.

Some "ecological neighborhoods" are safe and welcoming, providing such ecosystem services as clean water and flood control as well as natural areas to replenish the human spirit and protect native species. Other ecological neighborhoods, however, are not so benign: such hazards as forest fires, floods, hurricanes, and native predators may put their residents' safety, welfare, and property at risk. The effects of these mistakes, which situate human communities in ecologically inappropriate areas, are easily recognized after disasters, such as the Southern California fires of 2003 and the great Mississippi River floods of 1993. Christina Chance, a Southern California resident whose house was narrowly spared by the 2003 fires, captured this concept succinctly: "After you have weathered a fire, you learn how to select your home and your community."[10]

Respecting Natural Processes That Cross Boundaries

While human descriptions of landscapes, such as comprehensive plans and engineered site plans, often contain sharp, straight-line boundaries, nearly all other

Figure 1-3. The red-legged frog (*Rana aurora*) requires several different types of habitat, including small pools and moist woods, to complete its life cycle. These habitats may span several properties or even towns, but the frog has no knowledge of such human boundaries.

organisms perceive ecological systems as having leaky, fuzzy boundaries. For instance, the red-legged frog (*Rana aurora*) of the U.S. West Coast will, over its lifetime, use a variety of habitats, including small pools for growth as a tadpole and breeding as an adult, moist woods as its primary adult habitat, and the paths it travels between these sites. The frogs have no knowledge of the human-created property lines or jurisdictional boundaries that run through these habitats, although they may have to deal with human features on the landscape, such as roads and buildings (see Figure 1-3).

Even a natural boundary that seems clearly defined, such as the shoreline of a pond that divides land from water, is a porous barrier for many organisms. Frogs, toads, salamanders, dragonflies, damselflies, caddis flies, mosquitoes, and many other organisms spend the early part of their lives in the water and the later part on dry land, returning to the water to breed (for one example, see Figure 1-4). The entire sport of fly-fishing is built around two aspects of permeable ecological boundaries. Those who fly-fish create their lures so as to mimic adult caddis flies, mayflies, stoneflies, and other insects that spend their juvenile stages living under water and that return to water to lay their eggs. The artificial flies are intended to mimic these creatures because trout capture much of their food out of the water, eating flying adult insects.

Figure 1-4. Like many animals, the red-spotted newt (*Notophthalmus viridescens viridescens*) spends part of its life in freshwater habitats and part of its life on land. The red eft, the juvenile stage shown here, lives in moist forests, while the younger larvae and the adults are aquatic. The newt thus requires healthy aquatic and terrestrial habitats (and connections between them) to complete its life cycle.

Just as land use plans often show sharp boundaries even though natural boundaries are usually imprecise, they also tend to portray only one desired future scenario for a site or community, though in actuality the ecology of any area—even a city—is an unfinished book that can have any of a number of endings. Because of unpredictable events—whether global climate change, massive storms such as hurricanes or tornados, biological invasions such as kudzu or the Asian longhorn beetle, or just the ongoing ecological changes that take place in any system—the ecological future of an area is never certain. For example, no plan could have predicted with certainty which parts of our friends' subdivision in Colorado would be destroyed by fire, although an ecologist may have predicted that fire in this area was likely.

To account for natural processes and uncertainties when we plan, we must first seek to understand them. A recent study of Arizona's Desert View Tri-Villages Area conducted by landscape planner Frederick Steiner illustrates how *ecological due diligence* can inform land use planning.[11] The study emphasizes the importance of context, including not only maps of the Tri-Villages Area but also satellite images, maps, and elevation models of the surrounding landscape. It

reviews the area's land use history and possible future influences, discusses external impacts on the Tri-Villages Area (such as major climate patterns), and evaluates how local events may affect nearby watersheds. In short, Steiner describes the ecology of the Tri-Villages Area by beginning with the study area itself and then extending outward in four dimensions: across the landscape, down into the groundwater and soils, and into the past and the future. Reflecting ecological as well as human uncertainties, the study describes not just a single future planning outcome but a range of possible futures.

How can land use professionals create meaningful plans when the future is uncertain, boundaries are porous, and ecological events are often unpredictable? The first requirement is to recognize that ecologically based planning, like land use planning in general, rarely has a single correct solution—although it usually has many "wrong" solutions.

Second, planners and designers can seek out and use ecological information while understanding that much of this information is incomplete or limited in its predictive powers. In this regard, we can draw a parallel to other types of planning analysis, such as a market feasibility study. In such a study, data are collected on past real estate market trends and factors that are likely to affect future trends; models may be created and predictions made. Planners and developers must then make a decision based on the information in the study, recognizing that other factors—known, unknown, and unknowable—may all affect the ultimate marketability of the project.

Third, land use professionals should recognize the difference between *considering* an ecological variable in their plan and *controlling* it. Because ecological processes are uncertain, it is appropriate to build in a margin of safety when it comes to protecting people from the natural world and protecting the natural world from people.

Finally, and most importantly, planners and designers must ask the right questions about the ecological factors occurring within, impinging on, and emanating from their site. Throughout this book, we ask and answer these important ecological questions in order to provide a sound framework for improving the ecological compatibility of readers' future plans or developments.

2

An Introduction to Ecology and Biodiversity

Southeastern Arizona is one of the most beautiful parts of North America, with stunning deserts interspersed among pine-covered mountain ranges. The watershed of the San Pedro River, undammed along its entire 140-mile (225 km) length, stands out in this landscape for its exceptional biological richness (see Figure 2-1). In fact, this watershed of 3,700 square miles (9,600 square km) is arguably as biologically rich as any region of its size in the continental United States or Canada, with almost 400 species of birds, 82 species of mammals, and 43 species of reptiles and amphibians—all in an area smaller than Connecticut.[1] By comparison, the entire United States contains just 768 bird species, 416 mammal species, and 514 reptile and amphibian species.[2] The San Pedro watershed may be the most sought after spot in the United States by bird-watchers, and it is widely recognized among biologists as a jewel. But what does it mean to say that an area is biologically rich? And, once we determine that an area is biologically important, then what?

Biodiversity: The Stuff of Life

Biodiversity is the term used by conservation biologists to describe the entire diversity of life—encompassing all of the species, genes, and ecosystems on earth (or within a given area, as in the biodiversity of the San Pedro River watershed).[3] In practice, biodiversity is sometimes measured simply by counting the number