35 ELR 10100 2-2005

ELR
NEWS & ANALYSIS

Drafting Nature-Friendly Ordinances: An Ecological Checklist

by James M. McElfish Jr.

Throughout the United States, local governments have begun to recognize responsibilities relating to the health and function of the natural environments within their boundaries. Land use ordinances—including planning, zoning, and subdivision regulations—must in many places address issues of habitat conservation, ecological function, watershed management, and conservation of diverse plants and animals. Unfortunately, there has been a long-standing disconnect between biological understanding and land use regulation. Many elected officials and land use planners understand practical conservation requirements far less well than they do economic development strategies, community design, and fiscal policy.

But many local governments have begun to reconnect their interest in economic development with concern for healthy biological communities. Scientists have, at the same time, learned much about the requirements for functioning habitats. Land use planners and decisionmakers need this reliable information in order to be effective in writing ordinances to conserve and restore the lands and waters important for community well-being. The lessons of ecology and conservation biology can enable local decisionmakers to use familiar land use tools more effectively—to make development and redevelopment more "nature-friendly."

The colloquial term "nature-friendly" is really a stand-in for the technical term "biodiversity," which encompasses the "variety of living organisms and their populations, the genetic differences among them, and the natural communities and ecosystems in which they occur."[1] The latter term provides a way of thinking systematically about the environment in which we live. By focusing on living organisms and systems, it avoids the pitfalls of prior concepts like "undeveloped land" or generalized references to "natural resources."

Biodiversity places the emphasis upon *functioning systems* that sustain plants and animals, invertebrates, and microorganisms. A focus on biodiversity makes it possible for local governments to evaluate and employ tools that go beyond simply identifying and preserving a limited number of protected "critical areas" as their sole response to concerns about natural communities.[2] Biodiversity is a broader concept that requires consideration of the entire landscape; it commands attention to land management and development activities that occur outside specifically identified conservation areas as well as to those within such areas.

Qualities of Effective Nature-Friendly Ordinances

Local ordinances can contribute substantially to the conservation of biodiversity by supporting the creation and maintenance of conditions of ecological health on the local landscape. In order to do so, the ordinances must be based on well-understood ecological principles.

The leading causes of biodiversity loss and decline in the United States are the outright destruction of habitat and the impairment of habitat quality.[3] Many of these losses and impairments are the unintended byproducts of governmental and private decisions that failed to consider what is now known about ecological function. Articulating basic ecological principles will help communities avoid these unintended losses and take affirmative steps to conserve and restore those biodiversity features of their environment that add value regionally and locally. Local land use planning staff, planning and zoning boards, local legislative boards (councils, boards of commissioners, supervisors), and the many citizens and property owners across the country that participate in land use decisions that affect their communities are also affecting habitat and biological communities. Bringing the knowledge of ecology together with relevant land use tools will enable citizens to participate more effectively in the planning process and advocate changes to land

James M. McElfish Jr. is a Senior Attorney at the Environmental Law Institute (ELI), where he directs the Institute's Sustainable Use of Land Program. ELI's work on integrating biodiversity conservation with state and local laws governing development is supported in part by the Doris Duke Charitable Foundation.

[Editors' Note: This Article appears, in part, in the book Nature-Friendly Ordinances: Local Measures to Conserve Biodiversity*, by James McElfish, published in 2004 by ELI. The book can be ordered by either calling ELI at 800-433-5120 or logging on to the ELI website at http://www.eli.org.]*

1. Keystone Center, Keystone Dialogue on Biological Diversity on Federal Lands (1991).

2. The critical areas concept has remained influential in land use decisionmaking. The identification of "areas of critical state concern" was an important innovation in American Law Institute, A Model Land Development Code (1976), and "critical and sensitive areas" remain at the core of the American Planning Association's recent model state code provisions to enable local governments to address environmental concerns in land use regulation. *Special and Environmental Land Development Regulations and Land-Use Incentives*, *in* Growing Smart Legislative Guidebook ch. 9 (Stuart Meck ed., American Planning Ass'n 2002).

3. Bruce Stein et al., Precious Heritage: The Status of Biodiversity in the United States 242 (Oxford Univ. Press 2000). *See also* Environmental Law Institute (ELI), Conservation Thresholds for Land Use Planners (Envtl. L. Inst. 2003), *available at* http://www.elistore.org/reports_detail.asp?ID=10839 (last visited Dec. 1, 2004).

use regulations and ordinances that will conserve the biodiversity of their communities.

State enabling acts typically define the land use powers of local governments, and/or confer home-rule powers. In virtually all states there are explicit provisions in state law that recognize local government powers to conserve open space, natural resources, water quality, and provide in similar ways for the general welfare.[4] Some states have explicit requirements that such values be included in comprehensive plans and zoning ordinances, while others make such provisions permissive. Whatever the source, local governments exercise powers that can have a profound effect on the biological health of their lands and waters.

Identifying the powers of local governments is only the first step toward effective conservation. Selecting the right kind of tool for the task is critical. Areas important for biodiversity may be best protected through programs of land acquisition or through targeting of infrastructure spending. Other issues may be readily addressed through regulation. Judicial deference is most likely to be afforded to such local government actions when they are linked to enabling language, based on widely accepted scientific principles and understandings, and based on local studies that link the action to a defined problem.[5] Land use plans and ordinances that take biodiversity into account are most likely to be effective when they reflect three understandings.

First, they must articulate *clear standards* so that the goals, requirements, and rules are clearly understood. Vague generalities about concern for the natural environment expressed in a comprehensive plan, or ambiguous procedures or requirements in a zoning ordinance for reviewing development in areas of environmental concern, are both unlikely to result in effective implementation. The absence of clear goals and standards of performance leads to uncertainty. Where standards are vague, the ordinance becomes an obstacle and implementation becomes more difficult. This in turn makes the development process less fair, more costly, and unnecessarily complex. Experience has shown that biodiversity-friendly ordinances can be as specific as ordinances that establish all kinds of other rules for development. Where the ordinance articulates the goals and the means, the entire community can ascertain whether requirements are or are not being met, and land development interests can make decisions early in their planning processes that will benefit biodiversity.

Second, the land use ordinance must reflect *public commitment to a plan* for the area. Where a vision of the future includes room for the biodiversity of a community, people will support it. Public commitment to this vision then helps ensure accountability in implementation and the stability of the land use regime. Specifically, it reduces the pressure for rezonings, special exceptions, and approval of poorly thought-out development plans. Local public commitment to a biodiversity plan can also help sustain private, voluntary, and even state and federal actions that support the attainment of the local objectives. Local commitment to a biodiversity goal, and its embodiment in an ordinance, attract support from beyond the local government—in the form of funding, assistance, and compatible actions by other governmental and nongovernmental entities. These additional actions do not always occur but they are far more likely where the public commitment has been part of the ordinance process.

Third, *political leadership* is important. Often a community will realize that an investment in its biodiversity future is possible only after an elected official or planning commissioner articulates why attention to these community assets is important. Making the political case is essential in order to lay the groundwork for effective planning, enactment of ordinances, and implementation. Many of the communities that have enacted nature-friendly ordinances have one or more visionary leaders to thank for their progress. Sometimes the ordinance began as the vision of a single person in the local government; other times it came as the result of an education process begun by citizens outside of government; and in still others it was the creative local response to a state-initiated mandate—but a response that saw opportunity where others saw only obligation. The benefits of taking action must be clearly defined and explained to the public before the public will reciprocate with enthusiastic support for the action.

Land use ordinances that can incorporate conservation guidelines include comprehensive planning; various types of zoning, including overlay zones, incentive zoning, and performance zoning; subdivision regulation and site plan and development approval; growth management and infrastructure ordinances; conservation practice ordinances, including landscaping, floodplains, stream buffers, and vegetation management; and policies for the acquisition and subsequent management of publicly owned open space. The biological and ecological information should help inform the decision about what tool to use. Site-specific conservation may be best addressed through land acquisition, or through detailed subdivision requirements applicable to designated areas. Broader land conservation goals may be addressed through land use plans, zoning, vegetation ordinances, and other tools.

Conservation Guidelines for Land Use Ordinances

Scientists have made a great deal of progress in recent times in understanding how common land use choices affect conservation of biological diversity and the protection of ecological functions on the landscape. But local land use decisionmakers need to have this information in a form that they can use. Few planners and officials have time to make themselves masters of ecological science while performing their day jobs. And of those few with such knowledge, very few have time to re-create or summarize ecological learning for colleagues and constituents in a manner that will support decisions. Without a simple and accurate summary of current science, people may make decisions that reflect things they heard in school decades ago, or they may decide simply to forego dealing with an issue that appears complex.

Much has changed even since the 1960s and early 1970s when local land use regulations first began to take into account the conservation needs of communities as well as their development goals. Many of the conservation lessons that were understood then are still right, but others have been shown to be wrong. For instance, large-lot zoning was seen

4. ELI & Defenders of Wildlife, Planning for Biodiversity: Authorities in State Land Use Laws (2003), *available at* http://www.elistore.org/reports_detail.asp?ID=10917 (last visited Dec. 1, 2004).

5. John Nolon, New Ground: The Advent of Local Environmental Law 20-21 (Envtl. L. Inst. 2003).

some decades ago as a tool of choice for wildlife and forest conservation. Science has now shown that large-lot zoning often creates only the semblance of a wildlife habitat and forest without the function. Fragmentation of the habitat into separate two-acre or five-acre parcels has profoundly adverse and widespread effects even though the footprint of each physically disturbed area may be small. Similarly, decades ago wildlife biologists urged the creation and maintenance of more "edge" habitat (the margin of forest with field, for example) because edges tended to have more mammals and birds and larger aggregate numbers of species. Now it is well understood that edge habitat is good for some species (like deer, raccoons, cowbirds) and bad for others (such as forest-nesting migratory songbirds), and that the effects of the edge can be quite negative for some species even at a substantial distance away from the habitat edge.

The point is not to suggest that edge or large lots are always bad but to acknowledge that ecological science has given us tools to approach land use regulation with greater sophistication and precision than we could previously. One would scarcely practice medicine today using the state of medical knowledge in 1970—although even that would be preferable to no medicine at all. Similarly, land use planners should use the best biological understanding available today rather than rely on general assumptions about "open space" and habitat goals articulated in connection with 1970s-era planning innovations.

Conservation biology is a relatively recent field of scientific knowledge that seeks to discover the relationships between biology and the landscape, and to apply them to achieve conservation goals.[6] It applies scientific knowledge about habitat requirements, population biology, genetics, ethology, plant biology, ecological systems, soil science, hydrology, and related disciplines. Conservation biology and its related disciplines provide land use planners and officials with some basic tools that they can use in designing and administering ordinances governing land use and development.

Among the related disciplines is ecology. Ecology focuses on the natural systems and processes (including nutrient cycling and energy flows) that affect the landscape upon which life depends. The Ecological Society of America's Committee on Land Use recently distilled scientific understandings about these processes into a series of guidelines and recommendations for land use decisions.[7] This section draws on these guidelines and related scientific literature to articulate a limited set of conservation guidelines for those involved in the land use regulatory process. This section also draws upon additional lessons from conservation biology that have been generally recognized as guides for landscape management decisions.[8] There are two overarching guidelines and eight more specific land use guidelines.

Overarching Guidelines

It is important to examine proposed local decisions in two dimensions—the larger *regional landscape* and the potential effect of *changes in ecosystems over time*.[9] Planners and officials should always examine these two dimensions of their decisions as early in the process as possible.

Examine Impacts of Local Decisions in a Regional Context

Ecological communities of plants, wildlife, and the ecosystems on which they rely are not coextensive with political boundaries. Yet they are strongly influenced by actions that occur within a single political jurisdiction. In considering a land use decision, planners should identify the surrounding region that is likely to interact with the biologically significant areas within their legal borders. Conversely, they should identify the areas external to their jurisdiction that will be affected by their proposed decision.[10] They should also examine how adjoining jurisdictions are using and managing their lands and waters. Without this broader review, it will be difficult to predict the beneficial and adverse effects of land use decisions by the community, and it will not be possible to tailor local actions to larger ecosystem needs.

There is a substantial disconnect between the scale at which we need to plan and manage to effectively conserve biodiversity and the scale at which land use planning and decisionmaking is traditionally done.[11] Of course, the land use regulatory scale will vary from state to state. Some states provide for planning and zoning and land use regulation at the township and municipal level, others by county governments. But, in general, the relevant area in which biodiversity needs to be understood will almost always be

6. The term "conservation biology" began to be used in the early 1980s. Michael E. Soule, *What Is Conservation Biology?*, 35 BIOSCIENCE 727 (1985). The Society for Conservation Biology was founded in 1985 and began publishing its scholarly journal *Conservation Biology* in 1987.

7. Virginia H. Dale et al., *Ecological Principles and Guidelines for Managing the Use of Land*, 10 ECOLOGICAL APPLICATIONS 639 (2000) (also published in abridged form as ECOLOGICAL SOCIETY OF AMERICA'S COMMITTEE ON LAND USE, ECOLOGICAL PRINCIPLES, AND GUIDELINES FOR MANAGING THE USE OF LAND (2000)).

8. REED NOSS & ALAN COOPERRIDER, SAVING NATURE'S LEGACY: PROTECTING AND RESTORING BIODIVERSITY (Island Press 1994); RICHARD B. PRIMACK, ESSENTIALS OF CONSERVATION BIOLOGY (Sinauer Associates Publishers 1993). These conservation biology guidelines have been compiled in previous ELI publications including JESSICA B. WILKINSON & ELI, PROTECTING DELAWARE'S NATURAL HERITAGE: TOOLS FOR BIODIVERSITY CONSERVATION (Envtl. L. Inst. 1999); ELI, INDIANA'S BIOLOGICAL DIVERSITY: STRATEGIES AND TOOLS FOR CONSERVATION (Envtl. L. Inst. 1995); and ELI, OHIO'S BIOLOGICAL DIVERSITY: STRATEGIES AND TOOLS FOR CONSERVATION (Envtl. L. Inst. 1998) [hereinafter ELI, OHIO'S BIOLOGICAL DIVERSITY]. For ELI state biodiversity publications, see http://www.elistore.org/reports_list.asp?topic=Biodiversity (last visited Dec. 1, 2004).

9. The Ecological Society of America articulates four "principles" that are reflected in these two overarching guidelines:

> (1) Place Principle—"Local climatic, hydrologic, edaphic, and geomorphologic factors as well as biotic interactions strongly affect ecological processes and the abundance and distribution of species at any one place."
>
> (2) Species Principle—"Particular species and networks of interacting species have key, broad-scale ecosystem-level effects."
>
> (3) Time Principle—"Ecological processes function at many time scales, some long, some short; and ecosystems change through time."
>
> (4) Disturbance Principle—"The type, intensity, and duration of disturbance shape the characteristics of populations, communities, and ecosystems."

Dale et al., *supra* note 7, at 649-56.

10. *Id.* at 656-58.

11. *See* James M. McElfish Jr., *Learning From the Past and Looking Toward the Future*, *in* JOHN NOLON, NEW GROUND: THE ADVENT OF LOCAL ENVIRONMENTAL LAW 399-404 (Envtl. L. Inst. 2003) (discussing the jurisdictional mismatch and solutions available in land use law).

larger than one political jurisdiction. At least it frequently overlaps the boundaries of any one jurisdiction.

This spatial mismatch does not mean that resource protection can be ignored, nor that it can be left entirely to the state or federal governments. In the United States, land use powers reside at the local level. It is essential to use these powers in a way that takes the larger landscape into account. Declining to do so will relegate biodiversity to continued decline and will limit local planning for biodiversity to small systems of disconnected parks and overlay zones. Even though land use regulation is effectively limited to land use *within* the relevant political jurisdiction—as it almost always is, with the exception of those localities in a few states that have limited extraterritorial land use jurisdiction—the local jurisdiction should consider the effects of its actions on the larger biological landscape.

State agencies and conservation organizations often have information on the habitat needs of particular species. Some have identified watersheds or ecological regions that require particular attention. This information helps local communities assess the likely impact of their decisions over a larger area. Assessment of impacts, in turn, makes it possible for planners to incorporate this regional information into the local action and thereby make it more effective. Failing to identify the relevant ecological community and its stressors may result in the adoption of a local plan that has no chance of biological success. Conversely, failure to examine regional factors may lead to the adoption of land use constraints that are not necessary given the regional context.

Examine Impacts of Local Decisions Over Time, Considering Foreseeable Future Changes in the Landscape

Ecological systems and landscapes change over time. The Ecological Society of America recommends that land use planners plan for "long-term change."[12] Planners must take into account the fact that landscapes change and evolve over time: forests mature, lakes fill in, tornadoes create gaps and openings, beaches erode, domestic animals affect the population of wild animals, etc. Thus, planners must take into account the likely future condition of the ecosystem or landscape when making decisions and not simply assume that an area set aside as a bog will remain a bog without regard to changes in surrounding land uses, or that a habitat area for a particular species will always be occupied by the same species. It is essential to consider likely future changes on the landscape and the cumulative effects of adjacent land uses as well. Just as planners must make long-term projections about human population, economic development, infrastructure needs, water consumption, traffic, and other factors in order to plan effectively, so too do they need to plan for long-term landscape function.

Applying the Two Overarching Guidelines

These two guidelines apply to every land use decision. Planners should attempt to put the pending decision into the larger regional context in order to understand its effect on biodiversity. Even a small project (such as an office park or a road de-icing maintenance facility), if sited in the wrong place, can have a profoundly negative regional effect. Conversely, protection of a core feature (the recharge area for a spring system, the core habitat of a threatened bat, or the headwaters of a regionally important urban stream) can have profoundly positive effects in the larger landscape context.

Planners also should determine whether the land use decision being made today takes into account the fact that lands and biological communities change over time. They are subject to foreseeable natural and human-caused stresses that must be accommodated in some fashion. Effective planning for biodiversity conservation, like human place-making in the planning profession, recognizes that ecology—like human communities—is dynamic. Biologically sensitive planning is not the creation and maintenance of the landscape equivalent of a static museum diorama.

These overarching guidelines are as important for the planner from a small, older township as they are for the staff of a large rapidly developing county. Actions always affect landscapes, not just parcels. And good decisions attempt to anticipate future events, not assume that tomorrow will be just like yesterday.

Guidelines for Land Use Decisions

The following eight specific guidelines provide a checklist of practical choices that can improve the effect of local land use decisionmaking on the living environment. While they are not prescriptive, they do indicate which practices are more likely rather than less likely to support biodiversity conservation.[13]

Guidelines

1. Maintain large areas of contiguous habitat and avoid fragmenting these areas.
2. Maintain meaningful connections between habitat areas.
3. Protect rare landscape elements, sensitive areas, and associated species.
4. Allow natural patterns of disturbance to continue in order to maintain diversity and resilience of habitat types.
5. Minimize the introduction and spread of non-native species and favor native plants and animals.
6. Minimize human introduction of nutrients, chemicals, and pollutants.
7. Avoid land uses that deplete natural resources over a broad area.
8. Compensate for adverse effects of development on natural processes.

1. Maintain Large Areas of Contiguous Habitat and Avoid Fragmenting These Areas

Large habitat areas are important to maintaining key organisms and ecosystem processes. First, larger patches of habitat generally reflect greater species diversity than smaller

12. Dale et al., *supra* note 7, at 659.

13. Although the land use guidelines are principally drawn from the ecological guidelines developed by the Ecological Society of America's Land Use Committee, several have been expanded in recognition of related conservation biology principles, e.g., Guideline 6 reflects specific concerns that relate to the Ecological Society of America's guideline to "implement land use practices that are compatible" with an area's "natural potential."

patches of the same habitat. Larger patches have more local environmental variability, such as differences in microclimate, more structural variation in plants and vegetation, and greater diversity of topographic features, which provide more opportunities for organisms with different requirements and tolerances to find suitable sites within the patch.[14] Larger patches also tend to have greater species diversity because they contain a greater abundance of interior habitat than small patches, which often will contain only "edge" habitat. Interior and edge habitat can be very different, in terms of their exposure to pollution, sunlight, predators, habitat disturbance, roads, and other effects, therefore supporting different organisms. Larger patches, containing both interior and edge species, are more reliably diverse than smaller patches that often contain only edge species.[15] Larger patches are also better able to support species requiring larger home ranges, helping to conserve species such as large mammals that require greater areas to meet their food, water, and territorial needs than small habitat areas can provide.

Second, large habitat areas often contain a greater number of individuals of any species than smaller areas, due to the greater availability of food, nest sites, territory, and other resources in the patch. Larger populations tend to be more viable and persistent than smaller populations. Smaller populations are more vulnerable to extinction due to environmental fluctuations, demographic variation, inbreeding, and reduced gene pools.[16]

Avoidance of habitat fragmentation is equally important. Habitat fragmentation is a major cause of the loss of biodiversity, as it not only reduces overall habitat area, but also facilitates predation and disease and creates barriers to migration that reduce natural communities' resiliency.[17] Habitat fragmentation is understood to operate with "threshold" dynamics. This means that although gradual reduction of contiguous habitat may have gradual effects on the presence or abundance of a species, once the threshold is passed, the adverse effects can be dramatic. These land-cover changes are most likely to have substantial effects on species when habitat is low to intermediate in abundance. Under these conditions, small changes in habitat abundance may cause the connectivity threshold to be passed with strongly adverse effects on the species population.[18]

In order to minimize the threats from habitat fragmentation, it is critical to maintain habitat large enough to protect species of concern. The habitat areas should be large enough to maintain the minimum territories of the species, where possible, especially for species at the top of the food chain. Moreover, it is important to try to minimize edge and fragmentation effects. For example, conserved areas can be configured in more rounded parcels in order to minimize edge-to-area ratios and avoiding internal fragmentation by roads and fences. Communities should work to aggregate small nature reserves into larger conservation blocks to facilitate gene flow and migration among populations and to ensure adequate representation of species and habitats. Communities can also link protected areas with habitat corridors to foster connectivity among habitats.[19]

The importance of large areas does not negate the role of small areas nor does it absolve small local governmental jurisdictions from attention to this guideline. Small jurisdictions may contain portions of a larger habitat or may provide a crucial connection between larger habitat areas. Moreover, understanding the importance of conserving contiguous habitat areas can help a local government decide how to configure its design of a park, an overlay zone, or even a construction project on a brownfields site.

2. Maintain Meaningful Connections Between Habitat Areas

Many species require movement during their life cycles for persistence and survival. This can include daily movement within the home range for food, water, shelter, and escape from predators. It includes migration, in which certain species travel seasonally between breeding grounds and primary feeding areas. It includes metamorphosis, in which certain species must move from one habitat to another during the course of the life cycle. And it includes dispersal of both plants and animals, which allows a population to shift or extend its range, thereby increasing its resiliency in the face of ecosystem change.[20]

Maintaining large contiguous habitat areas is the single best way to ensure adequate species movement. However, population growth and related urban expansion and development have fragmented habitat and thus severely disrupted species movement in many areas. Primary barriers to movement include land conversion from natural habitats to developed environments, with their associated roads, power lines, noise, heat, and pollution.[21]

Where habitat areas have been fragmented, it is important to minimize the distance between protected habitats in order to ensure species movement. The distance between habitats and the nature of the transitional or connecting habitat between these separate areas influence the persistence of species.[22] It is important to locate conserved habitat areas in close proximity rather than widely spaced apart. Minimizing the distance also means increasing the permeability of existing barriers to movement between habitats. For example, roads block the movement of small animals and serve as the primary source of mortality for wide-ranging mammals. To reduce these effects, roads can be sited away from movement corridors, nonessential roads can be closed or limited in some natural areas, and design features such as underpasses and overpasses can be used to enable wildlife to safely cross highways.[23] Fences, like roads, also tend to restrict species movement and can be eliminated, minimized, or substituted for by "living" fences or shrubs that are more

14. Dale et al., *supra* note 7, at 655.
15. *Id.*
16. Primack, *supra* note 8; Noss & Cooperrider, *supra* note 8, at 59-62; *see also* ELI, Ohio's Biological Diversity, *supra* note 8, at 22.
17. Noss & Cooperrider, *supra* note 8, at 51-57.
18. Dale et al., *supra* note 7, at 655.
19. Noss & Cooperrider, *supra* note 8, at 150-56; *see also* ELI, Ohio's Biological Diversity, *supra* note 8, at 25.
20. Sheila Peck, Planning for Biodiversity 73-75 (Island Press 1998).
21. *Id.* at 76.
22. Leonard F. Ruggiero et al., *Viability Analysis in Biological Evacuations: Concepts of Population Viability Analysis, Biological Population, and Ecological Scale*, 8 Conservation Biology 364-72 (1994).
23. Peck, *supra* note 20, at 76-77.

porous. Other barriers to movement can be minimized by, for example, designing powerline rights-of-way to include wildlife crossings, reducing the width of such rights-of-way, and leaving forest connections intact in some of the stream valleys or other depressions over which such rights-of-way pass.

In addition to avoiding barriers and making barriers more permeable to species movement, it is also desirable to affirmatively link habitats by identifying and conserving wildlife corridors. Corridors such as riparian zones—vegetated strips and floodplains adjacent to rivers and streams—can effectively link populations from otherwise disconnected habitats. This may help to minimize local extirpations and genetic isolation of wildlife populations. When placed along migration routes, conservation corridors may help to ensure adequate movement of species to meet their food, cover, and breeding requirements at different times of the year.

Scientific information should be used to design corridors that provide meaningful and healthy connections between larger habitat areas. Corridors must be designed and managed to establish meaningful connections between habitat areas. For example, an intensively developed bicycle path greenway may not serve as an effective habitat corridor if it consists entirely of paved surfaces and mowed shoulders and berms. Some corridors can also have negative effects if they facilitate the spread of non-native species and disease to the detriment of isolated populations of native species.[24] Corridors often require active management to assure that they maintain their biological function.

3. Protect Rare Landscape Elements, Sensitive Areas, and Associated Species

The ecological importance of certain habitat areas may be much greater than suggested by their spatial extent. While rare landscape elements such as wetlands, watercourses, floodplains, or steep slopes may occupy a small area of land, they are frequently of high importance for a region's biodiversity. Rare landscape elements typically contribute a disproportionate share to the diversity of wildlife found in a given place. For example, in the southern Appalachian Mountains, 84% of the federally listed threatened and endangered terrestrial plant and animal species occur in rare ecological communities.[25] In order to protect these habitats, rare landscape elements need to be identified, usually via an inventory and analysis of vegetation types, hydrology, soils, physical features, and associated species.[26] Because habitat diversity is markedly reduced if rare landscape features are lost, it is important to focus conservation efforts on these critical areas and guide development toward areas with more common landscape features.

4. Allow Natural Patterns of Disturbance to Continue in Order to Maintain Diversity and Resilience of Habitat Types

Periodic disturbances such as storms, floods, and fires play an important role in maintaining patches in various stages and in maintaining the native plants and animals that co-evolved under the influence of those natural processes.[27] For example, "periodic burning and grazing is needed to maintain native species in tallgrass prairie, and ground fires are needed to ensure regeneration of oak forests." Without these disturbances, habitat can be lost through "natural processes of succession no matter how well it is protected from human use."[28]

Because these disturbances are ecologically important, it is sometimes not enough to simply leave nature alone. In other words, passive protection of habitat may not be enough. Where sources of natural disturbance have not been maintained, it may be necessary to emulate them to maintain the plants and animals native to those landscapes. "Prescribed burns might take the place of natural fires, logging might be used to simulate natural canopy gaps, livestock could serve as a surrogate for absent native herbivores, and releases of water from impoundments can be timed to mimic natural runoff."[29]

In order to allow these natural (or if necessary, emulated) disturbance patterns to take place, decisionmakers must ensure that these disturbances do not lead to catastrophic societal problems. Unfortunately, the continued expansion of human settlement in disturbance-prone landscapes is likely to result in increased conflicts between human needs and the maintenance of disturbance regimes necessary to sustain ecosystems. Therefore, land use plans must account for the occurrences and impacts of these disturbances.[30] For example, regulations must prohibit building on floodplains, account for sufficient buffer zones surrounding floodplains, avoid land use changes that affect natural water drainage, and prohibit building in fire-prone areas.

5. Minimize the Introduction and Spread of Non-Native Species and Favor Native Plants and Animals

Native plants and animals have great value, as they represent the conditions that co-evolved with the landscape. They are uniquely adapted to their surroundings, and they affect ecosystem processes and the persistence and viability of other plants and animals native to the area.

Introduction of non-native species can severely disrupt natural conditions and species composition in an area.[31] Non-native species (and particularly invasive exotic species) can alter community composition and ecosystem processes via their roles as competitors, predators, pathogens, or vectors of disease, as well as through effects on water balance, biological productivity, and habitat structure. Non-natives can even assume a dominant role, reducing the abundance of native species and creating conditions under which other non-native species can more easily spread.[32]

24. Dale et al., *supra* note 7, at 660.

25. *Id*. at 659.

26. *Id.*

27. Walter Reid & Kenton Miller, Keeping Options Alive: The Scientific Basis for Conserving Biodiversity (World Resources Institute 1989); Noss & Cooperrider, *supra* note 8, at 43-46.

28. Christopher Duerksen et al., Habitat Protection Planning: Where the Wild Things Are 15 (Planning Advisory Service Report No. 470/471) (American Planning Ass'n 1997).

29. *Id.*

30. Dale et al., *supra* note 7, at 659.

31. Meg Filbey et al., Halting the Invasion: State Tools for Invasive Species Management (Envtl. L. Inst. 2002), *available at* http://www.elistore.org/reports_detail.asp?ID=10678 (last visited Dec. 1, 2004).

32. Dale et al., *supra* note 7, at 660-61.

Non-native species are often introduced by changes in land use associated with land parcelization and development. Exurban development can promote the introduction of non-native species used for landscaping and can increase the abundance of roadways and other corridors that facilitate the spread of non-native species. Non-native plants and invertebrates as well as diseases can also be transported and spread by vehicles or boats.

In order to conserve, restore, or maintain a landscape of native species, native plant species should be planted in lieu of non-native species in urban, suburban, and other developed areas and should be used in public and private infrastructure projects whenever possible. Native species frequently become established more readily and require less maintenance than non-natives. Native species are also adapted to long-term variations in climate or disturbance regimes to which non-native species sometimes succumb. Maintaining the environmental conditions associated with native species may also limit the proliferation of non-natives.[33] Non-native plant species can be uprooted or otherwise eradicated to prevent their spread.

In addition, other preventative mechanisms can be taken to reduce the spread of non-natives. For example, the U.S. Forest Service has found that cleaning trucks or minimizing traffic in some sensitive areas during wet periods can greatly reduce the transport of certain forest pathogens.[34] Also, in order to minimize impact on native fauna, dogs and cats can be prevented from roaming freely, and garbage and other potential domestic food sources for native animals (such as bears) can be controlled to avoid fatal conflicts with domestic animals and human habitation.

6. Minimize Human Introduction of Nutrients, Chemicals, and Pollutants

Introduced compounds can directly impair biodiversity by killing terrestrial and aquatic species, by hindering their reproduction, or by changing their food supply. Such substances, which may originate from agricultural use, intensive urbanization, suburban development, lawn maintenance activities, municipal landfills, leaking underground storage tanks, failing septic systems, golf courses, and industrial activities, have drastic indirect effects as well. Some can cause reduced reproductive success and lower survival rates, disrupt the species composition of an area, or cause birth defects. For example, the input of large amounts of sediment and associated agricultural chemicals in many rivers and streams has caused a drastic decline in aquatic diversity.[35] Excess nutrients have resulted in drastic diminution of fish and invertebrate populations, with corresponding adverse effects on water-dependent terrestrial organisms. To minimize the effects of these harmful substances, it is critical to minimize applications and discharges where possible as well as to maintain buffer strips and vegetative areas surrounding wetlands and watercourses that can act as filters for pollutants.

7. Avoid Land Uses That Deplete Natural Resources Over a Broad Area

Depletion of natural resources—such as soil, water, and forests—can disrupt natural processes in ways that often are not reversible over fairly long periods of time. This guideline is aimed at major activities that can have long-term effects on underlying resources such as soil and groundwater. For example, some forms of intensive agriculture if conducted on highly erodible soils and steep slopes can result in the loss of substantial volumes of topsoil, which takes many years to regenerate. This may result in lands that cannot be restored to ecological productivity over the long term. Some logging practices, including overlarge clearcuts on very steep slopes, diameter-limit cutting of only the most profitable trees while leaving weaker trees for regeneration, and use of heavy equipment without adequate care for forest soils, can also have long-term ill effects on water quality and soils as well as impair the future forest resource. A community's overreliance on private wells and septic systems to support sprawling residential development in areas of limited water supply can result in difficulties both for long-term human water supplies and for the ability of an aquifer to recharge and support local springs, surface waters, and other waterway systems important for the local ecology. Similarly, allowing the paving over of large areas adjacent to stream banks can have lasting adverse effects on water quality, hydrology, habitat, and aquatic species.

In order to minimize natural resource depletion, it is important to first determine what resources are at risk. For example, in many parts of the United States, water is a scarce natural resource that should be carefully used to ensure the long-term health of both the human community and the ecosystem. Heavily water-consuming developments and industries may be incompatible with the resource's availability.[36] Growth must be compatible with the availability of water, healthy soils, forests, and other resources. It is important to avoid inappropriate land uses that deplete these natural resources over broad areas.

8. Compensate for Adverse Effects of Development on Natural Processes

Wherever possible, development should be designed to avoid negative effects on natural processes.[37] However, if authorized development may lead to losses of biological diversity, compensation through restoration measures within the same landscape is necessary and appropriate. Thus, wetland mitigation and restoration requirements can help to serve the objective of "no net loss" of wetlands in a given landscape.[38] On-the-ground compensation for other habitat losses by creation or protection of habitat areas can also help alleviate unavoidable impacts. It is important to recognize, however, that mitigation may not adequately replace or restore all functions and values of natural systems. Where compensatory mitigation is used to offset habitat loss, it is

33. *Id*. at 661.

34. *Id*. at 660.

35. *See generally* U.S. Geological Survey, National Water Quality Assessment (2001 and updates), *available at* http://water.usgs.gov/nawqa (last visited Dec. 1, 2004). *See also* ELI, Ohio's Biological Diversity, *supra* note 8, at 24.

36. Dale et al., *supra* note 7, at 659-60.

37. *Id*. at 661.

38. *See* ELI, Banks and Fees: The Status of Off-Site Wetland Mitigation in the United States (2002), *available at* http://www.elistore.org/reports_detail.asp?ID=10695 (last visited Nov. 23, 2004).

important to monitor mitigation sites to ensure that the desired ecosystem functions are being achieved.[39]

Conclusion

Local governments are in the biodiversity business whether they recognize it or not. Currently, few do. But the familiar planning and land use development tools that help communities address other aspects of land use and the general welfare of the community are no less useful in ensuring the function of the living environment around us.

Over the last three decades, ecologists and conservation biologists have advanced our scientific understanding of living organisms and their life requirements. Now they are seeking to communicate these findings to the community of land use planners and decisionmakers. The new discipline of conservation biology is an attempt to connect scientific understanding to real-world decisions on the landscape. And the work of the Ecological Society of America's Land Use Committee represents a similar effort by the nation's ecologists. At the same time, graduates of the nation's schools of planning and landscape architecture and a new generation of citizen activists and elected officials are realizing the critical importance of scientific knowledge to the long-term well-being of their communities. Whether or not they think in biodiversity terms, they recognize that a "nature-friendly" ordinance is generally to be preferred over one that is not. They are seeking to expand their knowledge of conservation by seeking practical direction.

Hundreds of counties and municipalities are recognizing that they can do something positive to ensure that the landscape continues to support plants, animals, insects, fish, reptiles, birds, amphibians, and many other forms of life that make their communities special. It is clearly a difficulty that the geographic scale of ecosystems and biological communities is generally much wider than the jurisdiction of planning boards and governing bodies. But states and conservation organizations are beginning to fill that knowledge gap. The two overarching guidelines on regional awareness and planning for long-term change, and the eight guidelines expressing current ecological knowledge and conservation biology precepts, will help local governments make the more detailed decisions—decisions about how to design zoning districts, what infrastructure plans to adopt, what subdivision regulations to apply, how to manage municipally owned lands in a sensitive way, and many others.

Put them on a card and carry them in your pocket, put them in the principles section of the natural resources element of your comprehensive plan, use them as guiding principles for your planning staff and your public works department. Make science-based decisions. Nature-friendly ordinances are the future of land use.

39. Commission on Environmental Quality, Office of the President, Biodiversity on Private Lands (Commission on Environmental Quality 1993).