How Greenways Work

A Handbook on Ecology

by Jonathan M. Labaree

originally published as a handbook in 1992 by

The National Park Service's
Rivers and Trails Conservation Assistance Program
and
QLF/Atlantic Center for the Environment

How Greenways Work is available through
The Conservation Fund's American Greenways Program
(703) 525-6500

and can be ordered from the Resource Library
of the Greenways section of their web site

Acknowledgments

This handbook draws upon *The Ecology of Greenways*, edited by Daniel S. Smith and Paul A. Hellmund (to be published in 1993 by the University of Minnesota Press). *The Ecology of Greenways* includes sections written by experts in the fields of landscape ecology, water resources, wildlife corridors, recreational design, site design, and design and management techniques. Specific attribution for subject areas is as follows:

Introduction and Case Studies
Daniel S. Smith

Landscape Ecology
J.F. Thorne

Wildlife Issues
Reed F. Noss

Water Resources
Michael W. Binford and Michael Buchenau

Site Design
Diana Balmori and Morgan Grove

Design and Management Issues
Paul A. Hellmund

While How Greenways Work serves as an introduction to basic ecological principles that apply to greenways, *The Ecology of Greenways* is a more detailed and technical volume.

Cover design by Victoria Bass.

Drawings and function symbols by Jane Shoplick.

Other illustrations by the author.

The author also gratefully acknowledges insight on determining width for movement corridors from Andrew Schiller of Breedlove, Dennis and Associates.

Within the National Park Service, overseers of this project were Christopher N. Brown, Steven H. Golden, Daniel S. Smith, and Samuel N. Stokes. Their suggestions, guidance, and comments make this handbook what it is.

Contents

Preface

William T. Spitzer
Chief, Recreation Resources Assistance Division
National Park Service

This is a handbook for those private citizens and public officials all over America who are working to create outdoor recreation opportunities and protect wildlife and our environment by establishing corridors of open space called greenways.

Greenways connect. They tie together people, parks, historic sites, and natural areas. They follow streams and rivers, ridgelines, abandoned rail lines, hedgerows, canals, and other transportation corridors. All are unique, created through local initiative and reflecting a consensus of community needs and concerns.

Preserving and restoring the natural world, especially near where we live and work, is one of the nation's most important conservation goals - and providing greenways may be one of the most beneficial and effective conservation strategies to accomplish it. To do this job effectively, we need to know about specific functions and values, and the respective planning and management strategies to implement them.

Through the emerging science of landscape ecology, we are learning more and more about the importance of the "linkage" that greenways provide in maintaining and restoring ecological processes and in maintaining the health of a landscape. Unfortunately much more research needs to be done before we can develop explicit criteria and strategies to protect the ecological functioning of each kind of corridor and environment for the nation's tremendously varied landscape and ecosystems.

This handbook is intended as a guide and introduction to the subject of using greenway corridors in enhancing ecological process.

Let us know how well it worked, your successes (and failure, if instructive!), new sources of information, and ideas. We will share them in an update. Good luck.

Contents

Introduction

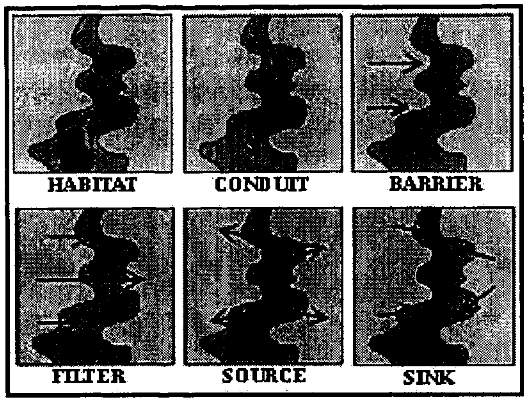
The purpose of this handbook is to serve as an introduction into ways in which we can design and manage greenways to fulfill their ecological potential. Greenways offer a whole range of benefits beyond traditional ones - open space and recreation - that are making greenways a popular conservation strategy. They can also meet very important ecological needs. Ensuring that a greenway fulfills its ecological potential rests upon understanding how a landscape functions and the role greenways can play in that functioning.

When we look out over what appears to us as a distinct piece of nature, such as an alpine meadow, we must realize that our view is but one of many. We cannot see groundwater flowing out of the surrounding wooded slopes bringing nutrients, minerals, and microorganisms into the meadow's soil. We do not notice the mice and ants constantly moving seeds within and beyond the meadow's edge. The hawk soaring overhead does not confine itself to the field, but hunts and nests elsewhere. The glacier that formed the valley, depositing sediment and creating ancient lakes, has long since retreated.

So much movement and activity should convince us to consider the meadow as an intricate series of connections with its surroundings rather than an isolated patch of grass and flowers. A change in perspective that will help us to grasp ecological functioning is to see nature as a system of interconnected, interdependent, and ever-changing parts.

"Part" can refer to any number of elements within a landscape: a river, mountain, field, glacier, lake, barrier island, forest. Basing land conservation on ecological criteria means protecting not just these physical elements, but their interactions, or functions, as well. Greenways, being linear, are best suited to protect parts of the natural landscape which are also linear. These linear landscape elements are called environmental corridors. The challenge for conservationists is to design greenways so they protect corridors and their functions.

Of the many functions of corridors, this handbook focuses primarily on those functions related to wildlife and to water resources (elaborated in chapters III and IV). Before diving into specifics, however, it is important to understand the way in which our modifications to the environment influences natural balances (covered in Chapter I) and the ecological functions of corridors that we hope to maintain when creating greenways (Chapter II).



These symbols, representing the ecological functions of greenways, appear frequently in the text.

There is much more to establishing a greenway than locating it properly in the landscape; managers will be continually challenged in their effort to maintain their greenway's ecological functioning (such issues are the subject of Chapter V). While this handbook emphasizes ecology, other issues are important to people involved in greenway projects: designing the greenway so it is a pleasant place to be; avoiding conflicts between different uses; or capitalizing on economic benefits that a greenway can bring to a community. There are references throughout the text to other publications which deal with these topics in greater depth.

Chapter One
Impacts of Development

An underlying principle of conservation is that utilizing natural resources does not, in itself, pose a threat to the environment. It is the manner in which we do it that dictates whether our activities are detrimental or benign. Our modifications have created new patterns in the landscape which can threaten ecological functioning. Dramatic shifts in the ratio between natural and developed land has lead to:

loss of natural space;

fragmentation of natural spaces;

degradation of water resources; and

decreased ability for nature to respond to change.

Loss of natural space

Developing land for human needs reduces the amount of natural space. As natural space diminishes, so does habitat diversity -- the great variety of forests, prairies, bogs, and deserts which exist in nature. The result is both a decline in the number of species and fewer individuals of those species which do survive. Converting midwestern short- and tallgrass prairies over to agriculture, for example, has lead to a decline in native grass and wildflower species and in animals adapted to prairie habitat. We have substituted native species with ones which better meet our needs: cattle, corn, wheat, pigs. While this has had advantages for society, it has upset the natural balance of those ecosystems. We are generally able to sustain our agricultural systems only by replenishing fields with fertilizers and groundwater and by protecting them from pests with chemicals.

Fragmentation of natural spaces

Development has an indirect impact on land it leaves untouched. As we convert land, we fragment it into smaller and more isolated patches of natural space (see Figure 1). The new pattern that we have created on the landscape greatly alters the way in which natural systems function. Wildlife and flora populations have evolved, and continue to evolve, in conjunction with their surroundings. They have developed strategies to exploit their environment in order to fulfill basic life needs. Different species utilize different habitats. Any change in their habitat will affect their ability to survive. Two major reasons why fragmentation is destructive are increase in edge habitat and greater isolation between patches.

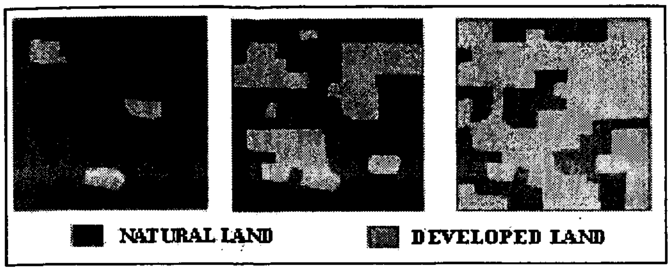


Figure 1. As land gets developed, seen here from left to right, the natural space that remains becomes highly fragmented.

Edge habitat Edge habitat is an area of transition between two types of land cover. Edges exist throughout nature in many forms and are often areas of high biological diversity because two or more natural communities come together and influence each other. Plants and animals which live in each community utilize the edge as does a distinct set of species specifically adapted to ecological edges. Edge habitat that results from human activity can be disruptive. While some species are adapted to edge habitat, there are many species which require interior spaces, shielded from the influence of surrounding lands. Fragmentation changes the natural balance between edge and interior. Indeed, heavily fragmented landscapes may not have any interior habitat at all.

Isolation of patches In fragmented landscapes, development has left many wildlife populations isolated from needed habitat and other individuals of their species. Some species are not sensitive to humans and survive quite well in our presence. Other species, however, will not come near even a modest development or fly across a cultivated field. Although natural land may still exist in fragmented landscapes, species sensitive to people cannot move freely in order to utilize it. This not only cuts individuals off from habitat, it makes it harder for them to sustain their populations by creating barriers between potential mates.

Degradation of water resources

Wetlands and lands along rivers perform a variety of critical functions related to water resources: controlling floods, trapping sediments, filtering out toxins and excess nutrients, and supporting rich assortments of wildlife and plant species. These same areas are often favored for development because they are flat, arable, or have high residential value. Developing wetlands and riparian zones reduces their capacity to fulfill their functions and threatens the health of the environment.

Decreased ability for nature to respond to change

Species naturally respond to changing conditions both in the climate and in their predators and prey. Development has decreased nature's ability to respond to these changes in two fundamental ways: reducing genetic diversity and hindering wildlife movement. As populations of plant and animal species decline, their genetic diversity also declines, diminishing their ability to adapt to long-term change. In addition to genetic alterations, plants and animals respond to their changing environment through movement. Animals move in response to events such as wildfires or hurricanes. As climate changes, both plants and animals move to stay in environments to which they are adapted. Fragmentation hinders this movement. Pollution may be increasing the rate of change beyond nature's ability to respond.

Chapter One
Impacts of Development

An underlying principle of conservation is that utilizing natural resources does not, in itself, pose a threat to the environment. It is the manner in which we do it that dictates whether our activities are detrimental or benign. Our modifications have created new patterns in the landscape which can threaten ecological functioning. Dramatic shifts in the ratio between natural and developed land has lead to:

loss of natural space;

fragmentation of natural spaces;

degradation of water resources; and

decreased ability for nature to respond to change.

Loss of natural space

Developing land for human needs reduces the amount of natural space. As natural space diminishes, so does habitat diversity -- the great variety of forests, prairies, bogs, and deserts which exist in nature. The result is both a decline in the number of species and fewer individuals of those species which do survive. Converting midwestern short- and tallgrass prairies over to agriculture, for example, has lead to a decline in native grass and wildflower species and in animals adapted to prairie habitat. We have substituted native species with ones which better meet our needs: cattle, corn, wheat, pigs. While this has had advantages for society, it has upset the natural balance of those ecosystems. We are generally able to sustain our agricultural systems only by replenishing fields with fertilizers and groundwater and by protecting them from pests with chemicals.

Fragmentation of natural spaces

Development has an indirect impact on land it leaves untouched. As we convert land, we fragment it into smaller and more isolated patches of natural space (see Figure 1). The new pattern that we have created on the landscape greatly alters the way in which natural systems function. Wildlife and flora populations have evolved, and continue to evolve, in conjunction with their surroundings. They have developed strategies to exploit their environment in order to fulfill basic life needs. Different species utilize different habitats. Any change in their habitat will affect their ability to survive. Two major reasons why fragmentation is destructive are increase in edge habitat and greater isolation between patches.

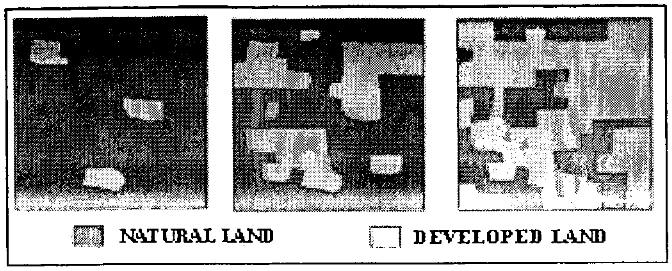


Figure 1. As land gets developed, seen here from left to right, the natural space that remains becomes highly fragmented.

Edge habitat Edge habitat is an area of transition between two types of land cover. Edges exist throughout nature in many forms and are often areas of high biological diversity because two or more natural communities come together and influence each other. Plants and animals which live in each community utilize the edge as does a distinct set of species specifically adapted to ecological edges. Edge habitat that results from human activity can be disruptive. While some species are adapted to edge habitat, there are many species which require interior spaces, shielded from the influence of surrounding lands. Fragmentation changes the natural balance between edge and interior. Indeed, heavily fragmented landscapes may not have any interior habitat at all.

Isolation of patches In fragmented landscapes, development has left many wildlife populations isolated from needed habitat and other individuals of their species. Some species are not sensitive to humans and survive quite well in our presence. Other species, however, will not come near even a modest development or fly across a cultivated field. Although natural land may still exist in fragmented landscapes, species sensitive to people cannot move freely in order to utilize it. This not only cuts individuals off from habitat, it makes it harder for them to sustain their populations by creating barriers between potential mates.

Degradation of water resources

Wetlands and lands along rivers perform a variety of critical functions related to water resources: controlling floods, trapping sediments, filtering out toxins and excess nutrients, and supporting rich assortments of wildlife and plant species. These same areas are often favored for development because they are flat, arable, or have high residential value. Developing wetlands and riparian zones reduces their capacity to fulfill their functions and threatens the health of the environment.

Decreased ability for nature to respond to change

Species naturally respond to changing conditions both in the climate and in their predators and prey. Development has decreased nature's ability to respond to these changes in two fundamental ways: reducing genetic diversity and hindering wildlife movement. As populations of plant and animal species decline, their genetic diversity also declines, diminishing their ability to adapt to long-term change. In addition to genetic alterations, plants and animals respond to their changing environment through movement. Animals move in response to events such as wildfires or hurricanes. As climate changes, both plants and animals move to stay in environments to which they are adapted. Fragmentation hinders this movement. Pollution may be increasing the rate of change beyond nature's ability to respond.

Chapter Two
Greenway Functions

This chapter introduces some basic concepts which are important for understanding the role which corridors, and hence greenways, play in the landscape.

Nature is a series of interactions among plants, animals, and even air, soil, and water. A healthy environment depends upon keeping those interactions intact. The threats described in the previous chapter result from alterations we have made in the landscape that hinder natural processes. The challenge for conservationists is to ensure that we orient future development in a way which sustains natural processes. Protecting environmental corridors through establishing and managing greenways represents one method (to be used in conjunction with other approaches) to safeguard vital ecological processes.

If we are to understand truly our impact on the landscape, we must learn to see it not as a bunch of independent pieces a woodlot here, a river there, and a grassland yonder but as intricately connected parts of a larger whole. Any given part of a landscape affects other parts. When designing a greenway, it is important to consider what impact it will have on natural processes. A greenway like their natural counterparts, environmental corridors can operate in six basic ways:

- as **habitat** for plant and animal communities
- as a **conduit** for plants, animals, water, sediment, and chemicals;
- as a **barrier** preventing movement;
- as a **filter** allowing some things to pass while inhibiting others;
- as a **source** for animals or seeds which move to other parts of the landscape; and
- as a **sink** for trapping sediment, toxins, or nutrients.

Since it may not be possible, or desirable, to design a greenway to fulfill all six functions, planners should identify which ones are most important to the site. For example, in a heavily developed area, a greenway can offer scarce *habitat*. Severely fragmented landscapes would benefit from a greenway designed to be a *conduit* allowing animals to reach isolated protected areas. A greenway which is along a river should be planned to *filter* excess nutrients from surrounding lands (in which case it also acts as a *barrier* preventing movement of sediments and a *sink* storing them). One proposed along an abandoned rail bed in the midwest can act as a *source* of native prairie grasses.

Greenways as habitat

A species' habitat may include many different types of vegetation and geography, such as wetlands, upland forests, and fields. A greenway's ability to provide habitat will depend upon its size, location, and the needs of native species. A greenway that is 200 feet wide will generally contain habitat for fewer species than one in a similar location that is half a mile wide. A 200-foot-wide greenway along a river, however, that includes a variety of vegetation, may provide habitat for as many species as a wider one in a setting with less natural variation. Some species require more natural area than others. A 200-foot-wide greenway, therefore, may provide plenty of habitat for salamanders, beetles, and frogs, but very little for bears, eagles, and elk.

Greenways as conduit

Conduits are areas in the landscape along which water, animals, plants, and people move. A river is among the most obvious examples of a conduit. Water carries sediment, nutrients, leaves, insects, bacteria, and plankton along with it. Acting as a conduit to connect otherwise isolated parts of the landscape is an important function of greenways. Such connections will allow animals to reach necessary elements of their habitat. As animals or water move along a greenway conduit, seeds do as well, thus aiding in plant dispersal.

Greenways as barrier

While a greenway may be a conduit to some things, it presents a barrier to others. Again, a river serves as an example. Small animals, such as mice, may be unable to cross a river. Or its moist habitat may be inhospitable to creatures that prefer drier surroundings. Even very narrow corridors, such as hedgerows, can present a physical barrier of impassable habitat for some species.

Greenways as filter

A filter prevents the passage of some things but allows the passage of others. Filtering can occur in a greenway either perpendicular to its axis or along its length. Large animals, able to traverse a river, for example, can pass across a riparian greenway, but small ones may not. Similarly, some animals may be able to move along the entire length of a greenway, while others may fall victim to predators or find the habitat inhospitable. The next chapter deals extensively with a greenway's potential to filter sediments and nutrients from surface and groundwater.

Greenways as source

A greenway may act as a source, providing surrounding land with a variety of things. A riparian greenway may be the only source of water in an otherwise arid landscape. In human-dominated areas, even narrow strips of relatively undisturbed land, such as hedgerows or steep slopes, may be a source of seeds of either native or non-native species.

Greenways as sink

A greenway acts as an ecological sink when something moves into it but does not travel back out into the surrounding land. Perhaps the most significant way a greenway can be a sink is by trapping sediments and nutrients carried in surface and groundwater. This function is, however, dependent upon a specific time frame because sediments may eventually wash downstream during a dramatic flood, or nutrients absorbed by vegetation will re-enter the soil and atmosphere when the plant decays.

Chapter Three
Greenways and Wildlife

The two major ecological functions that greenways can fulfill for wildlife are providing **habitat** and acting as **conduits**. Proper design will increase the probability that a greenway will be an effective conduit.

Greenways and wildlife -- habitat

A greenway's potential to serve as habitat for native plant and animal species will depend upon its size and the condition of the surrounding land. Generally, the larger the greenway, the more species and individuals it will support. All habitat within a greenway, however, may not be suitable for some species because of edge effects.

Edge effects are particularly acute where a cultivated field borders a native forest or woodlot. Increased light and wind at the forest's edge leads to drier soils, more light-favoring species, and more blowdowns. Species that are adapted to the moist soils and shady environment of the forest interior are unable to survive in edge habitat.

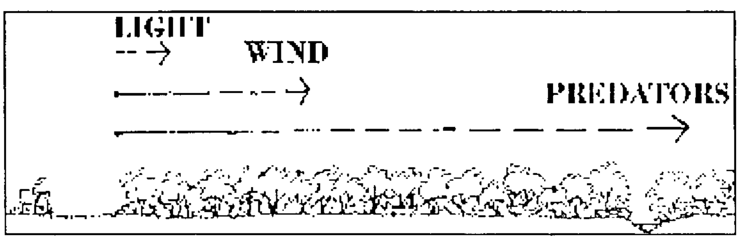


Figure 2. Edget Effects. Increased light, wind, and predators characterize the edge of a forest where it borders a field. Each effect penetrates differently into the forest as indicated by the arrows.

Not only are many species adapted to interior habitat, but they are not adapted to the presence of species which inhabit edge. More edge increases the ability of non-interior species, such as the common grackle or brown-headed cowbird, to feed on interior ones or to compete with them for nesting sites or food. Edge species also introduce a new set of diseases to which interior species may be vulnerable.

Vegetation and wildlife react to the effects of edge differently. While changes in vegetation at edges, due largely to increased light and wind, may extend 35 to 100 feet into a temperate forest, researchers have noted adverse effects to wildlife as deep as 1,000 to 2,000 feet from a forest's edge (Wilcove, et al., 1986). This difference stems, at least in part, from predators venturing into interior habitat (see Figure 2).

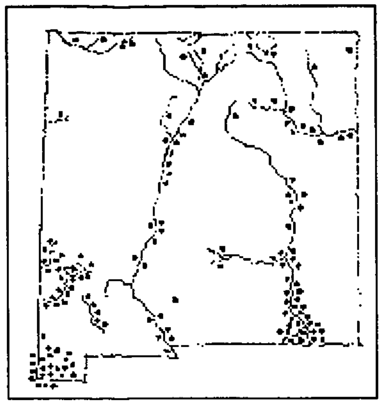


Figure 3. Location of rare and endagered species in New Mexico.
The vast majority of rare and endangered species in New Mexico exist within or near riparian ecosystems. (after a map in MacKintosh, G. ed. 1989. *Perserving Communities and Corridors*. Washington, DC: Defenders of Wildlife)

Because the problem of edge effect is so acute, many greenways will be most useful for animals whose natural habitat is linear. River systems are a good example. Riparian ecosystems support high densities of vertebrates. They often contain more species and more individuals than drier surrounding land. Seventy-five percent of the vertebrates in Oregon and Washington's Blue Mountains depend upon, or prefer, riparian habitat (Thomas, et al., 1979). In arid and semi-arid lands, river corridors are extremely important. In Arizona and New Mexico, eighty percent of the vertebrate species depend upon riparian zones during at least part of their life (see Figure 3) (Johnson, 1989).

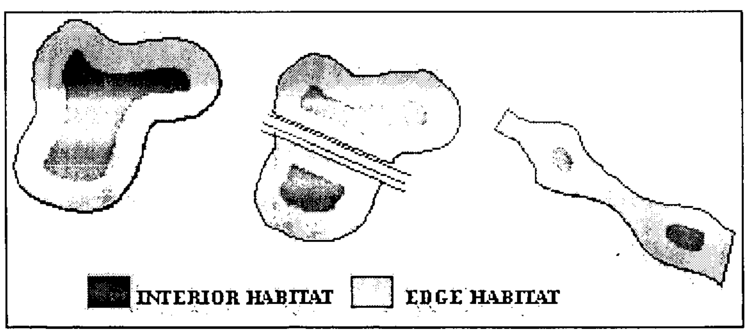


Figure 4. Effects of fragmentation and narrowness on interior habitat.
The drawing at left shows a natural patch of land with edge effects penetrating around its perimeter. In the middle, a road has dissected the same patch, greatly reducing the amount of interior habitat. A greenway, at right, will often have little interior habitat because it is too narrow to overcome the effects of edge.

In agricultural landscapes, hedgerows, shelterbelts, and fencerows offer what may be the only wooded or shrubby habitat. Rows of shelter trees provide habitat for birds in Minnesota (Yahner, 1982). In Great Britain where agriculture dominates much of the landscape, roadsides are critical breeding habitat for many species of rodents, birds, and insects (Way, 1977). In a landscape with little natural land, a greenway, no matter how narrow, will be beneficial.

5. Hedgerows in an agricultural landscape. Many agricultural landscapes have rows of shrubs or trees along the edges of fields or planted as protection for homes and livestock. Photo: USDA Soil Conservation Service

Greenways and wildlife -- conduit

A wildlife population has two basic requirements for long-term survival: enough natural space to satisfy life needs of individuals and a population which can sustain itself. Fragmentation threatens many wildlife species' ability to meet both those requirements. Properly designed and managed greenways, however, can help wildlife overcome effects of fragmentation by:

- increasing the effective size of protected areas;
- creating access to different habitats; and
- connecting wildlife populations.

Increasing effective size of protected areas -- Wildlife species require a certain amount of habitat to survive -- they need to roam in order to breed and to find food and nesting, den, or burrow sites. Generally, the larger the animal, the greater its home range. An animal's home range will also depend upon its trophic level -- how high on the food chain it resides. Predator species usually have larger home ranges than herbivores of equivalent size. Since a wildlife population needs to be of a certain size to remain healthy, the amount of natural land it requires is proportional to the home range of its individuals.

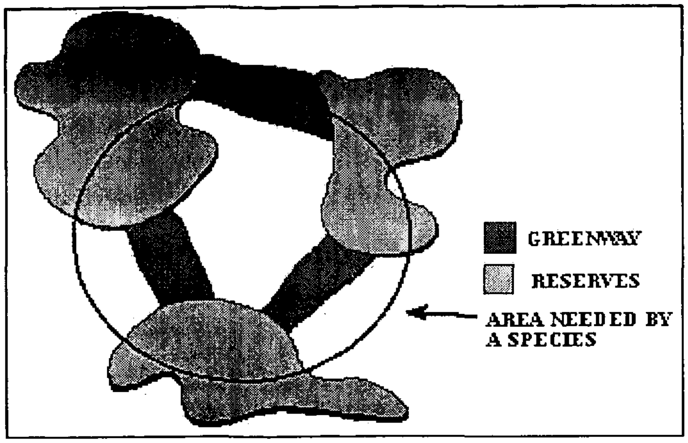


Figure 6. How greenways increase the effective size of existing reserves.
The circle represents a theoretical amount of land a species needs. Any one of the reserves is not large enough. If greenways connect the reserves, there may be enough protected land for the species.

In fragmented landscapes, the needed amount of natural land may exist but be divided into isolated pieces. If greenways connect smaller parcels, animals can move among them, utilizing their total area, not just that of an individual patch. The "effective size" of each patch thus approaches the total size of all the connected natural areas. In this way, greenways can increase the effective size of a series of protected areas (see Figure 6).

Creating access to different habitats -- Natural space alone is not enough to ensure wildlife conservation -- diversity of habitat types is also critical. Species such as raccoon, white-tailed deer, river otter, and gray fox use more than one kind of habitat (see Figure 7). Thus, a patch of natural land may correspond to a species' home range, but might not contain all the habitats the species needs. Patterns of development often create barriers between necessary habitats, hampering wildlife's efforts to survive. Connecting patches which support different habitats with greenways can greatly enhance an individual's opportunity to reach the diversity of habitats it needs to survive.

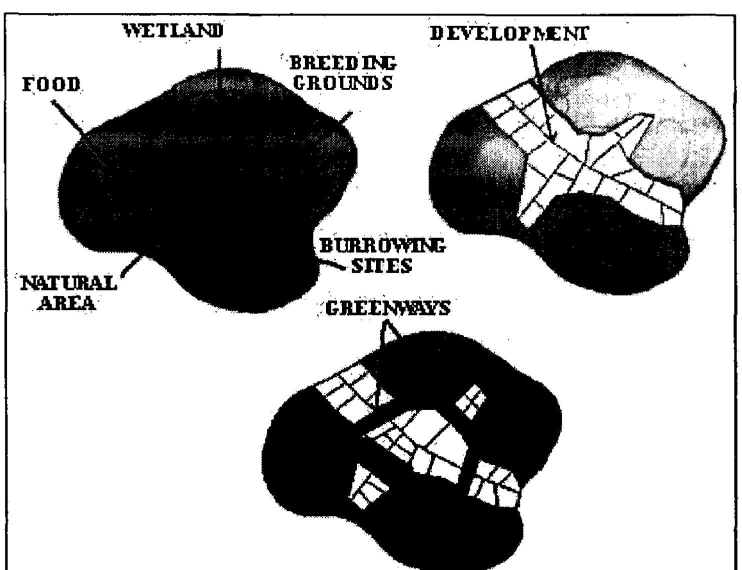


Figure 7. Isolation fromhabitat. The figure in the upper left depicts a patch of natural land interpersed with habitats. In the upper right, a development has left important habitat intact, but has prevented animals from utilizing it. Connecting habitat patches with greenways, as in the bottom figure, gives these species the opportunity to use all the undeveloped landscape.

Connecting wildlife populations -- The same forces which separate individuals from needed natural lands can also prevent them from finding other members of their species. As forest interior shrinks, the distance between members of a species increases. Intervening land becomes a barrier if it harbors predators, or if species are naturally unwilling to traverse it. Isolation from others in their species affects wildlife populations in two ways: demographically and genetically.

Demographic effects of isolation will occasionally lead wildlife populations living in small patches of forest (or prairie, wetlands, desert) to die off in that immediate area. Causes include disease, disturbance, increase in predators or competitors, and fluctuations in birth and death rates. Small wildlife populations are more likely to succumb to these random events than large ones. These localized extinctions occur naturally. If a population of white-footed mice, say, dies off in a small patch of woodland, individuals from a nearby patch will recolonize the now vacant woodlot.

By creating small and isolated patches of natural space, fragmentation can divide a once large wildlife population into smaller, more vulnerable populations. Fragmentation also makes it more difficult for members of other populations to recolonize vacated habitat. While greenways may not make demographically driven local extinctions any less likely, they can provide conduits to make recolonization by other populations easier (see Figure 8).

Figure 8. Providing access to other populations. The illustration shows two patches of forest connected by a corridor. If a population dies out in one patch, then individuals can make their way from the other and recolonize it.

Wildlife populations can be susceptible to a number of genetic effects from isolation. Close relatives are more likely to mate as populations become isolated. Common results of breeding between relatives are increased juvenile mortality, decreased fertility, and reduced overall ability of a species to survive. Small populations are likely to become more genetically similar -- the potential for change and adaptation is lost. A species may lose a rare genetic trait which could help it survive under different circumstances.

In most species, some individuals will disperse away from their natal population to ensure genetic diversity. In fragmented landscapes, greenways can play an important role in making such dispersal possible. Given the opportunity to fulfill their natural tendencies to disperse, individuals will bring new genes to a population with declining genetic diversity. A greenway can provide that opportunity.

Adapting to long-term changes -- As the climate changes, whether due to human influence or not, plants and animals will have to disperse and find areas to which they have adapted. While a single, locally oriented greenway may help connect two populations of a wildlife species, it is unlikely to provide the substantial linkages necessary for plant and animal species to respond to long-term climatic changes. When possible, cooperating with neighboring towns or jurisdictions could ensure that greenways join up at municipal boundaries, thereby establishing broad-scale connections extending beyond the borders of a given town.

Designing greenways as effective conduits

A greenway will only act as a conduit for wildlife if individuals are willing and able to travel along it. Width and quality play major roles in determining whether animals will use a greenway for movement. A greenway must also offer a continuous link with as little disturbance from roads and other development as possible.

How wide? There is not a magic width at which a greenway will begin to act as a conduit. As a general rule, wildlife ecologists recommend that there be a one-to-one ratio between edge and interior habitat in a conduit greenway. Drawing on figures presented on page 12 relating to edge effects, a greenway would need to be 400 feet wide to balance 200 feet of edge habitat (100 feet of edge on either side) with 200 feet of interior habitat.

Many species use riparian corridors for movement. Thus, establishing a greenway in a riparian zone will offer a good opportunity to protect its conduit function. Proper width of a riparian movement greenway depends largely on the nature of the riparian zone. Such a greenway should be wide enough to include the entire riparian zone (see Figure 10, page 23) on at least one side of the stream and interior habitat in associated uplands. Ideally, this interior habitat would exist in a one-to-one ratio with edge habitat.

Species sensitive to humans will need wider greenways for movement than will more tolerant ones. Therefore, another factor determining width for a greenway is the species most likely to use it. Large predator species may require greenway widths measured in miles. Other species such as the blue jay will travel along a narrow hedgerow (although capable of flying across open lands, jays, like many birds, prefer to remain in woodlands).

Quality of the greenway is as important as width. Not all species should be able to move along a corridor. Exotic species may move along corridors creating competition for native ones. Maintaining a greenway with native plant species and minimizing the amount of edge habitat will help ensure that exotic species will not displace desirable ones.

The quality of surrounding land will also influence how effectively a greenway will function as a conduit. The greater level of development in lands adjacent to the greenway, the wider the greenway will need to be to overcome disturbance from noise, people, and pets (dogs and cats are very efficient predators).

Guidelines for designing greenways to provide habitat and act as conduits

Habitat:

Identify the needs of the most sensitive species for which the greenway is to provide habitat. Greenway managers should be particularly aware of species which are sensitive to edge effects because greenways will generally contain a lot of edge habitat.

For the most part, greenways will not, by themselves, provide good habitat. Therefore, do not allow greenway projects to proceed at the expense of other initiatives which will provide habitat, such as large reserves.

Conduits:

Concentrate on matching natural characteristics of the landscape -- both in terms of species composition and connecting patches of habitat which were originally connected but human development has left isolated.

Ensure that the greenway meets the movement needs of the species which are most sensitive to people. It may be necessary to build tunnels under roads or include specific habitat which a particular species requires.

General requirements:

Undertake a natural resource inventory before planning and designing a greenway. The inventory will identify the area's native mixture of species and special plants, animals, and habitats.

Follow the inventory with a review of research done on the local landscape. Such a review may reveal studies concerning conservation needs of native plant and animal species or local impacts of edge effects.

Sources of information:

For specific information about native plant and animal species, conservation biologists at a nearby college or university, U.S. Fish and Wildlife Service biologists, and agricultural extension agents can be of great assistance.

Harris, L.D. 1984. The Fragmented Forest: Island biogeography theory and the preservation of biotic diversity. Chicago: University of Chicago Press.

Saunders, D. A., R. J. Hobbs and C. R. Margules. 1991. "Biological consequences of ecosystem fragmentation: A review." Conservation Biology. 5 (1): 18-32.

Soulé, M. E. 1991. "Land use planning and wildlife maintenance: Guidelines for conserving wildlife in an urban landscape." APA Journal. 57 (3): 313-323.

The journal Conservation Biology, published by the Society of Conservation Biology, is an excellent source of contemporary scientific research relating to conservation.

Chapter Four
Water Resources

This chapter has three sections: functions, context, and design.

Section One: Functions

Many of the existing and proposed greenways in the United States at some point follow the course of a river. As such, they offer a terrific opportunity to protect riparian ecosystems and the variety of ecological roles they perform. By acting as a sink, a filter, a barrier, and a source, a greenway can maintain the following functions which are associated with riparian zones:

- flow moderation;
- nutrient and sediment filtration;
- temperature regulation;
- bank stabilization; and
- food and habitat provision for aquatic communities.

Flow moderation

Riparian zones moderate water flow through the connected processes of physical resistance from vegetation, absorption of water into the soil, transpiration of water from plants, and groundwater discharge. When a stream floods, it overflows its banks and inundates the surrounding flat land, known as the flood plain. If that area is nothing but farmland or pavement, the river will maintain much of its velocity. If, on the other hand, the flood plain is covered with its natural vegetation, it will act as a sink, absorbing the flooding river's energy and much of its water (at least temporarily). Riparian plants will slow the flood down as stems and trunks block the water's progress. As the stream's velocity subsides, more water seeps into the flood plain's rich soils. This water is either released into the atmosphere by plants, evaporated from the soil when the flood subsides, or discharged slowly as it makes its way through the ground to the stream again.

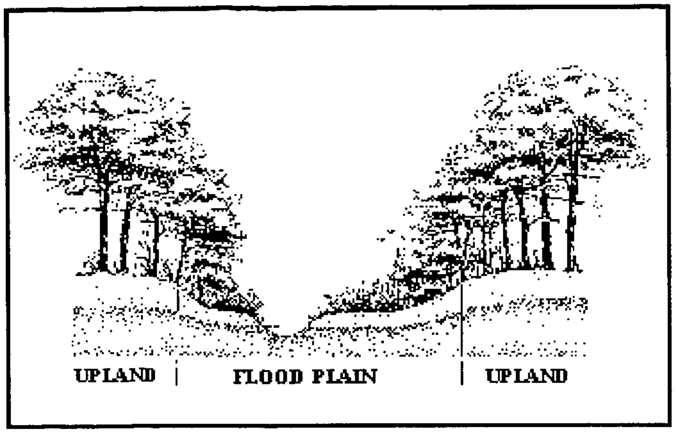
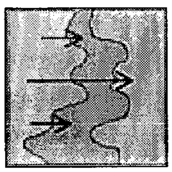


Figure 10. Delineation and compositioin of the riparian zone.

Top of Section

Top of Chapter



Nutrient and sediment filtration

Riparian zones filter out nutrients and other harmful chemicals from surrounding land uses. A common problem in developed areas is increased nutrient load in rivers from industrial, residential, and agricultural areas. Riparian systems can reduce the nutrients in water coming from surrounding lands. A riparian zone's ability to filter a given nutrient depends upon such factors as its vegetation, slope, the initial concentration of the nutrient, and how the nutrient is moving. Nutrients and toxins can be attached to sediment or dissolved in surface runoff, groundwater, or soil water (water stored in the soil).

Riparian vegetation filters nutrients and toxic metals by trapping sediment particles to which they are attached. Phosphorus and nitrogen, two nutrients whose overabundance can harm river and lake systems, most frequently travel into these systems attached to sediment. Vegetation and microorganisms in a healthy riparian zone will consume many of the nutrients which are dissolved in surface runoff or in soil water. Woody riparian vegetation removes a significant amount of nitrogen from groundwater as well. Numerous studies indicate the effectiveness of riparian systems at removing nutrients and other chemicals, such as oils, insecticides, and herbicides.

Top of Section

Top of Chapter

Temperature regulation

One of the ways in which riparian zones regulate a stream's temperature is shade. Overhanging and near-stream vegetation lowers water temperatures by blocking solar energy. Many fish species, including trout and salmon, are adapted to the resulting cool water. Trout, for example, will not survive in streams with average summer temperatures above 72° F. Removing vegetation can seriously affect those species' chances of surviving both because they are adapted to cool temperatures and because warmer water retains less dissolved oxygen than cool water.

Top of Section

Top of Chapter

Bank stabilization

A riparian zone stabilizes a stream's banks primarily by providing structure through its system of roots. The deep fluvial soils left by millennia of sediment deposition allow plants to send their roots deep into the earth. The resulting tangled mass of underground vegetation traps soils and protects them from the eroding forces of running water.

Top of Section

Top of Chapter

Food and habitat for aquatic communities

Vegetation protects not only soil, but offers important cover to fish and other aquatic species. They can hide under fallen logs or in the shade of an overhanging tree. The lush riparian vegetation is also a source of food as leaves and other debris fall into the stream.

Figure 11. A riparian zone in an agricultural landscape. The riparian zone depicted here will filter agricultural waste flowing out of surrounding fields. If the fields extended to the water's edge, the banks

would be susceptible to erosion. Water temperature would also increase due to more direct exposure to the sun.

Top of Section

Top of Chapter

Section Two: Context

A riparian zone's ability to perform its functions will depend heavily on:

- the status of upstream vegetation;
- land use of associated uplants; and
- the successional stage of the riparian zone itself.

Status of upstream vegetation

If there is development along a stream, natural riparian zones downstream of that development will bear the brunt of stronger floods, no longer moderated by upstream vegetation. Similarly, increased amounts of sediments, nutrients, and toxins may overtax the remaining riparian zones and degrade them beyond their natural ability to restore themselves.

Top of Section

Top of Chapter

Land use of associated uplands

Activity in uplands also has enormous impact on riparian zones. Devegetation in these areas often increases the amount of water reaching the river system. If uplands have been converted to industrial, residential, or agricultural use, runoff from those sites can be laden with toxic and nutrient-rich waste. While riparian zones are effective filters of such waste, they can be overwhelmed.

Top of Section

Top of Chapter

Successional stage

The state of the riparian zone itself is also important. Mature forests are frequently at equilibrium, meaning that the amount of nutrients going into the system is equal to the amount coming out. Forests dominated by younger trees, however, will retain the many nutrients which the trees need to grow. In these cases, the effectiveness of riparian habitat at performing its filtering functions may be reduced compared to a riparian zone with younger trees.

Figure 12. Successional stages of a forest. The illustration shows basic stages of succession from an open field to an old growth forest.

Top of Section

Top of Chapter

Section Three: Designing greenways to protect riparian functions

How do you design a greenway to protect riparian functions? Unfortunately, there is not a set answer which tells us exactly how wide a greenway needs to be or precisely what parts of the landscape to include. Ideally, a greenway should maintain the riparian corridor in as natural a state as possible. Using that broad statement as a guide, we can develop some notion of what should be included in a greenway.

How wide?

Efforts should concentrate on including the flood plain, its banks, and portions of the uplands in the greenway system on at least one side of the river and preferably both sides. It is during this journey from upland to river channel (see Figure 10 on page 23) that most of the filtering of sediments and chemicals takes place. A river's flood plain, bank system, and associated uplands generally increase in magnitude relative to the size of the river. Rather than seeking a universally applicable standard for greenway width, therefore, planners should base greenway design on local conditions. Ideally, they should undertake a study which demonstrates how much sediment is entering the riparian zone, and how wide the zone needs to be to filter out an acceptable percentage of sediment and nutrients.

For example, a study in a coastal watershed in Maryland revealed that the first 250 feet of the riparian zone filtered out most of the sediment from runoff. Nearer the stream, the amount of filtering decreased (Karr and Schlosser, 1977). A similar study from North Carolina showed that more than fifty percent of sediment in runoff from agricultural fields was filtered in the first 300 feet of riparian vegetation (Lowrance, et al., 1985). In both cases, the slope of the surrounding agricultural fields was relatively slight (0 - 7%). Riparian corridors will have to be wider where the source of runoff is large, slope is greater, human use more intense, or nothing is done in the fields to prevent erosion. These many variables make a study of the site very important.

Top of Section

Top of Chapter

What else?

Width should not be the only consideration -- there are specific sites within the landscape which have direct bearing on riparian functioning. Intermittent tributaries (streams which form seasonally in response to increased rainfall or snow melt), gullies, and swales through which water reaches the stream should be included in a greenway because they are important components for the filtering and flow moderation functions of the riparian zone. Keeping these areas intact and vegetated with native species is important. Areas of aquifer recharge or discharge, such as wetlands, seasonally wet soils, or springs, are also critical. Identifying recharge and discharge sites generally requires a professional hydrologist and should be part of an initial site study.

Top of Section

Top of Chapter

Guidelines for maintaining riparian functions in a greenway

Make greenways continuous along the river.

Cover both sides of the waterway if possible.

Include in the greenway the river's flood plain, riparian forest, associated wetlands, intermittent tributaries, gullies, and swales.

Undertake a comprehensive study of the site's sediment and nutrient flow to establish how much is entering the riparian zone and how much it will need to filter. If this is not possible, rely on results from studies done at similar sites.

Base greenway width on comprehensive study of the site. Riparian greenways which neighbor intensive land uses such as clearcutting, monoculture, or shopping malls will need to be wide enough to absorb excess nutrients and toxins.

Maintain a band of natural vegetation along the stream bank to protect its temperature moderation function.

Avoid mowing streamside vegetation, as this practice will decrease its filtering effectiveness.

- Supplement natural sediment trapping function of the greenway with retention basins or vegetated berms where necessary.

Supplement, if necessary, natural nutrient filtering functions of the greenway with a tree harvesting regime (derived in consultation with local forester and ecologist) to maximize nutrient uptake.

Sources of information:

Dunne, T. and L. B. Leopold. 1978. Water in Environmental Planning. New York: Freeman and Co.

U.S. Department of the Interior, National Park Service. 1988. Riverwork Book. Philadelphia: National Park Service.

Chapter Five
Other Design Considerations

Chapters III and IV dealt with how to design greenways to fulfill specific ecological functions such as habitat, conduit or filtering. This chapter covers a more general set of issues (not necessarily unique to greenways) of which greenway designers and managers should be aware:

- designing and managing for change;
- exotic plant and animal species;
- the impact of roads;
- interactions between people and greenways;
- maintaining ecological health with the greenway.

Addressing each of these topics involves both design and management. It is therefore worth considering what those two terms mean and how they are related. Although the term design has many connotations, we are most interested in design as it relates to greenway shape, composition, and context. As seen in the previous chapter, meeting ecological goals requires careful consideration of how wide the greenway is, what parts of the landscape it connects, and what kind of habitats are included. These are design considerations.

Design also has an important aesthetic component. Diana Balmori, a contributing author in Ecology of Greenways, says of design: "It solves the functions and tries to go beyond to an aesthetic dimension, attempting to make something beautiful, and tries to ground that form into something meaningful to the society that creates it."

Management picks up where design leaves off. Managers ensure that the greenway continues to meet the objectives laid out in the design process. For example, one task might be to maintain the quality of habitat through such measures as controlling exotic species, reducing human impact through trail maintenance, or replanting to native vegetation.

Top of Chapter

Designing and managing for change

Natural systems are in constant flux -- they are always changing. The Greek philosopher Heraclites said that you can never step in the same river twice. He could have said the same for a field, tundra, forest, or desert. But that is easy to forget because we rarely see change occur. Nonetheless, it is critical to allow natural change to take place in protected areas because it is an inherent aspect of nature. There are both design and management considerations which can help achieve that goal.

Designing for change

The very idea of planning for change may seem contradictory. How can we possibly plan for something if we do not know what it will be? Greenway designers can respond to uncertainty and anticipate the long-term needs of the natural community by:

- protecting secondary habitat;
- identifying and protecting areas of rich biotic diversity; and
- including a diversity of habitats within the greenway.

Secondary habitat -- Secondary habitat refers to areas which plants and animals need occasionally. For example, a fire could destroy part of a greenway and prevent animals from using it as a movement corridor until vegetation grows back. In a landscape where that corridor is the only way for wildlife to move between important habitats, the fire could be devastating. Guarding against such an event requires including more than one movement corridor in a greenway system so if one is temporarily unusable, wildlife can use another.

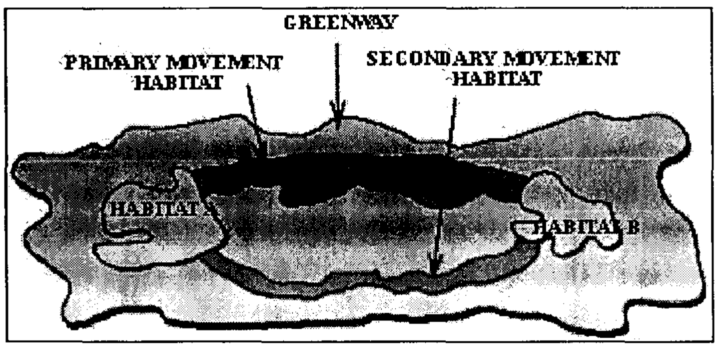


Figure 13. Secondary movement habitat within a greenway. Animals moving from Habitat A to Habitat B may prefer the primary movement habitat because it is wider. In the event of a disturbance, however, this route may become unusable. Without an alternate route (the secondary movement habitat), Habitats A and B will be isolated from each other.

Centers of diversity -- As change occurs, some new species will arrive and others will leave. We do not know which ones and therefore cannot plan for specific future conditions. We can assume, though, that a patch of land which supports a rich diversity of species now will probably continue to do so in the future. Concentrating our efforts on preserving areas in the landscape which are currently centers for high diversity will help ensure that a greenway will continue to protect the range of species adapted to contemporary conditions, whatever they might be.

Diversity of habitats -- Another way to manage for change is to include a high diversity of habitats in a greenway. Habitat may change very dramatically over a small distance. This is particularly true where physical characteristics in the landscape cause gradients in environmental conditions. An example of an environmental gradient is altitude. Temperatures drop as altitude increases; soils often become thinner; average wind velocity rises; and precipitation usually increases. In the northern hemisphere, conditions at the top of mountains resemble lower altitude habitats farther to the north. Including a mountainside or other gradient in a greenway, therefore, will add greatly to its diversity of habitats.

For a greenway to act as a conduit for plants and animals, habitats should be as continuous along its length as possible. Patterns of habitat diversity, therefore, should be oriented along the greenway, rather than across it (see Figure 14), to maintain connectivity. In the case of the mountainside, a greenway which goes up its slope rather than along its valley may not act as an effective movement corridor.

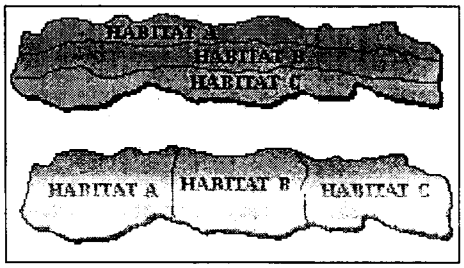


Figure 14. Habitat distribution along a greenway. When possible, habitat should be contiguous along the length of a greenway (top) rather than across it (bottom).

Top of Subsection (Designing for Change)

Top of Section (Change)

Top of Chapter

Managing for change

Including secondary habitat, centers of diversity, and diverse habitats in a greenway are all design considerations: they involve creating greenway boundaries to meet certain goals. Once a greenway is created, there are management strategies which also address the issue of maintaining change as part of the greenway's ecology.

Some plants and animals are adapted to events which we consider disasters, such as floods or fires. From nature's point of view, removing such events from a landscape may be the real disaster. Greenways, many of which are in or near urban centers, will exist largely in human-dominated landscapes. We have taken great pains to remove floods, fires, and other natural disturbances from our cities and towns. Thus, greenway managers may not only have to plan for unforeseen change but they may also have to ensure that changes that were once part of the natural landscape continue to occur.

An example of change is fire. Fire is an important part of many landscapes, such as western forests and midwestern prairies. Removing fire from ecosystems where it occurs naturally disrupts the processes to which plants and animals are adapted. For example, the cones of some trees open up and disperse their seeds only when subjected to the extreme heat of a forest fire. Without fire, it is more difficult for those tree species to reproduce themselves. There are also many plants and animals which are adapted to take advantage of conditions which prevail after a forest fire. One such plant, fireweed, gets its name from its dependence upon fire. In ecosystems where plants and animals are adapted to periodic fires, greenway managers may want to initiate a prescribed burning routine which mimics natural occurrence of fire.

Adaptive management -- Once we accept that change is an inherent part of nature, we must adopt management techniques which reflect that reality. One such technique is called adaptive management. In this approach, managers monitor the greenway to understand what changes are taking place, which management policies are improving ecological functioning, and which are not. By responding to new information from monitoring efforts, management becomes a dynamic process of adapting to ecological and cultural changes. Areas which are facing heavy recreational impact can be closed off or restricted to walkers. Scientists may discover that animals only use part of the greenway as a corridor, allowing more area to be opened up to the public.

Top of Subsection (Managing for Change)

Top of Section (Change)

Top of Chapter

Exotic species

Designing and managing a greenway to account for and accommodate change is a challenge made greater because some changes are ecologically desirable while others are not. Change that is naturally a part of the ecosystem should be encouraged but change resulting from human intervention should be avoided. Among the more detrimental changes that can occur is the invasion of exotic species.

Most exotic species depend upon people to survive -- we bring them, intentionally or accidentally, to their new destination and we create conditions which favor exotic species by altering the landscape. A healthy landscape in its natural condition can usually ward off exotic species. Where native species are not adapted to new, human-generated conditions, exotic species may be able to replace them.

Causes of invasions

Greenways, especially ones in urban or suburban landscapes, will be susceptible to invasion by non-native species. This is due largely to human disturbance either within the greenway or in the surrounding land. Heavy recreational use can create disturbance within a greenway. Surrounding land can influence a greenway primarily through edge effects. Opportunistic plants and animals thrive in disturbed lands, competing with original inhabitants for food and shelter. Exotic species often thrive in their new environment because they have no predators or are more adapted to human landscapes.

Dangers of invasions

While exotic species pose a threat to greenways, the threat to other protected areas such as nature preserves may be even more serious. If a greenway fulfills its role as a conduit, it can provide exotic species access to important natural areas. Exotic species threaten biodiversity in protected areas because they can dominate their new landscapes to the exclusion of many native species.

Based on the understanding that exotic species can be damaging to an ecosystem, one of the design and management priorities for a greenway project should be to maintain the native mix of species. Preventing invasion, or eradicating unwanted species is likely to be site-specific, depending greatly on the species involved.

Top of Section (Exotic Species)

Top of Chapter

The impact of roads

Although roads will provide many people access to greenways, they present a unique set of design and management problems. Due to effects of edge and fragmentation, a road affects the landscape well beyond its pavement's edge. Two major impacts that a road can have on its surrounding landscape include:

- providing dispersal routes for unwanted species; and
- constituting dispersal barriers for native species.

Dispersal routes for unwanted species

Cleared areas along roads usually represent disturbances in native habitat. Weedy species benefit from these conditions and may migrate along roads to colonize areas previously out of their reach. In some cases, however, highway medians and other clearings may represent remnant patches of native habitat. This is particularly true in the midwest where cultivated fields have replaced much of the native prairie. Conservationists may want to cooperate with highway departments to implement a management plan that favors native species. Many states restrict mowing in highway medians, for example, to allow native wildflowers to grow.

Dispersal barriers for native species

Roads frequently pose barriers to species which would normally move throughout the landscape. Some species -- desert rodents and even black bears -- rarely cross a road.

Road kills cause huge losses in some species. American motorists daily kill more than a million vertebrates (Lalo, 1987). Proper management, however, can reduce roadkill. In an effort to decrease highway mortality of migrating mule deer, the Colorado Division of Highways built a tunnel under Interstate 70 near Vail. Fences prevent deer from crossing the interstate and channel hundreds of them into the tunnel and safely under the highway. (See Santa Monica Mountains Case Study.)

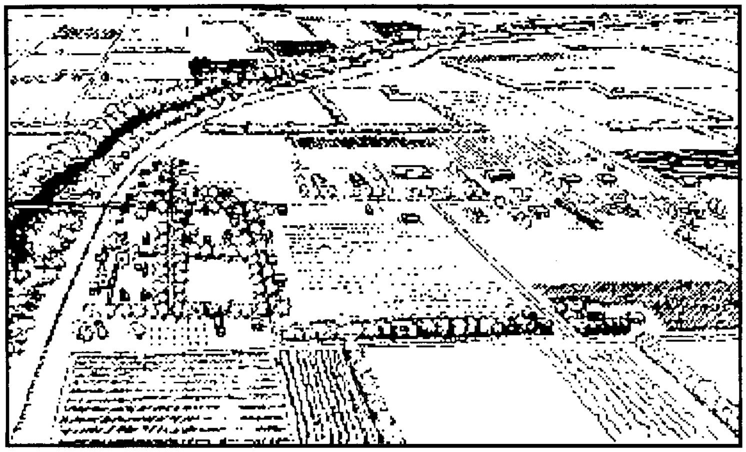


Figure 16. A riverside greenway. A greenway along a river, such as this one, is not likely to intersect as many roads as one created through the mosiac of fields.

Top of Section (Roads)

Top of Chapter

Interactions between people and greenways

It is easy to fall into the assumption that everything we do harms the environment. Our relationship with nature is complex and it is unfair to over-emphasize our harmful impacts. Indeed, greenways, and their popularity, bespeak a very different tradition. Greenways represent our desire to foster a healthy and responsible attitude toward nature. Two ways in which greenways can help achieve that goal is through providing opportunities for recreation and public education.

Recreation

Greenways are well suited for outdoor recreation. Their linear shape corresponds to trails and rivers. Since greenways use land efficiently, and do not necessarily require strict protection, they can fit into many urban and suburban landscapes where access to natural spaces is limited. Heavy recreational use, while socially beneficial, can produce short-term ecological damage in the following ways:

- compacting soil;
- increasing erosion;

- trampling and mutilation of vegetation;
- disturbing wildlife; and
- introducing non-native species.

Soil compaction -- The weight of walkers and runners compacts the soil along a trail. Once compacted, soil can no longer hold as much water or support as much life, such as roots and microorganisms. Generally, compaction is limited to the immediate vicinity of a trail.

Erosion -- Compaction and loss of vegetation often leads to erosion because rain which would have soaked into the ground instead runs over its surface, building velocity and carrying sediment. Erosion also often occurs where trails traverse steep slopes or meet the water's edge.

Damage to vegetation -- Trampling and mutilation of vegetation is most common at campsites and other areas of intense use such as scenic overlooks. Small saplings, twigs, and near-surface roots get damaged. People sometimes carve initials and other graffiti into mature trees.

Disruption of wildlife -- Although narrow, trails can produce effects associated with fragmentation. While not as damaging as roads or land conversion, trails can increase edge habitat, bringing edge species into contact with interior ones. Trails offer access to people, whose presence wildlife may learn to avoid, further reducing the amount of land species can utilize.

Introduction of non-native species -- Disturbed environments, such as trails and campsites, favor opportunistic exotic species over native ones. Hikers, bikers, and horses offer a mechanism for these species to reach disturbed areas.

Avoiding and controlling use -- Minimizing effects of recreation can follow two approaches: avoiding sensitive areas and controlling use of trails and other facilities. A natural resource inventory identifies sensitive areas. Wetlands, steep slopes, thin soils, and river- and streambanks are all examples of conditions which are not appropriate for heavy recreational use. Siting trails along the edge of forests reduces fragmentation and provides diverse views.

Physical constructions or signs can control use where it is unavoidable or desirable. For example, wetlands are among the most interesting aspects of the environment but sensitive to human use. They afford wonderful educational opportunities to see rare plants and animals. Wooden platforms, bridges, and causeways protect the habitat while allowing people a view. Greenway planners should also consult design manuals which describe different trail materials such as crushed native stone or pine needles.

Some types of use are more damaging than others. Given similar numbers of users, walking is the most benign use while motorized all-terrain vehicles tend to be the most destructive. Between the two extremes lie horseback riding and mountainbiking. Not all these uses are socially compatible, although this will depend on the region. Whatever combination of uses are socially and ecologically acceptable, it is important that they be restricted to planned and maintained trails. It is often tempting to cut one's own path to get a view or to walk alongside a friend.

Top of Subsection (Recreation)

Top of Chapter

Public education

Environmental -- Our interactions with the environment are not one-way. We may have an impact on nature, but it also has an impact on us. Greenway designers can capitalize on this by placing trails and signs to educate the public. Education extends a greenway's conservation potential beyond such direct benefits as combating fragmentation or protecting riparian functions. The attention a greenway focuses on a community's river, for example, can inspire residents to form a citizen monitoring group. Keeping a close watch on a river's water quality allows a community to pinpoint sources of pollution. Through disseminating information, organizing, and lobbying, such efforts lead to cleaner waters and a healthier environment.

Cultural -- Cultural heritage can be part of a greenway along with natural heritage. Old homesteads, locks, mills, or fishing weirs attract people's attention and interest. Emphasizing such forms of development, which often relied greatly on the natural landscape, highlights a community's past and its connection with the environment. People's natural pride in their heritage will make the greenway a fixture in the community. Signs and educational programs can play a major role in enhancing public awareness and support.

Top of Subsection (Education)

Top of Section (People/Greenway Interactions)

Top of Chapter

Maintaining ecological health

Bolstering the ecological health of a landscape is the major reason for designing and managing greenways with ecological functions in mind. We may have some vague notion of what ecological health means, but faced with complexities like exotic species or successional change, what appears healthy may not be. A greenway can be green, yet not support the full diversity of species native to the area. Conversely, a greenway may be dry and sparsely populated, yet represent a region's natural vegetative cover and wildlife.

The appearance of ecological health is site- and function-specific -- so how do we know what is natural and how do we ensure that natural conditions prevail? In some cases, where development has dramatically changed the environment, it may not be possible to determine what "natural" means. But, when some remnant natural space exists, it can serve as a guide to how the ecosystem should function.

Careful study of the natural sites leads to understanding of what "ecological health" means for the altered site. The study should concentrate on the number of species, what species are represented (composition should match natural balances of plant-, insect-, and meat-eating species), and the number and health of individuals. This technique measures a site's biological integrity against a similar one from its own region. It does not favor increasing diversity or populations to match popular notions of healthy ecosystems, rather it reflects natural balances.

Top of Section (Ecological Health)

Top of Chapter

Guidelines

Change

Design a greenway as part of a larger network of corridors to provide secondary habitat.

Include a variety of habitats such as different soil types and wetlands.

Design the greenway to include ecological gradients such as elevation change.

Exotic Species

Replant disturbed sites with native species.

Generally, avoid the temptation of planting exotic species even though they may have beneficial qualities such as erosion control or high-quality food source.

Engage in active management schemes such as intentional burning where these conditions are favorable to native plant species.

Always manage a greenway to benefit native species. This may require consultation with local botanists who study local plant and animal species and their needs.

Roads

Strike a balance between siting greenways near roads to provide adequate public access and keeping the number of places where roads intersect the greenway to a minimum to reduce detrimental impacts associated with roads.

Work closely with highway departments to coordinate land use management.

Interactions between people and greenways

Base trail and facility location on the sensitivity of greenway habitats, and the type and intensity of use.

Avoid wet or shallow soil and steep slopes to minimize soil erosion and disruption of vegetation from recreational use.

Utilize trail surfacing materials which are permeable and do not compound drainage and erosion problems.

Minimize trail width in forest interior to minimize its impact.

Avoid building trails that run along the length of greenways designed to be movement corridors or habitat for wildlife; instead create spurs branching off from a main trail outside the corridor or habitat to provide access to viewing points.

Locate areas of potential intensive use along the greenway's boundaries.

Expand a visitor's understanding of nature to include the whole landscape by integrating areas of cultural significance or scenic vistas.

Provide low-impact pathways through the greenway's various habitats and geological or cultural features.

Ecological Health

Undertake as complete a natural resource inventory as possible.

Identify a site which is ecologically similar to the greenway's to use as a basis for comparison.

Sources of information

Change

It may be necessary to consult with ecologists with an understanding of the local landscape to identify areas of diversity or secondary habitat. Certainly, such experts should be consulted before undertaking such active management measures as prescribed burning or intentional clearing.

McHarg, I. L. 1969. Design with Nature. Garden City, NY: Doubleday/Natural History Press.

The Conservation Fund will publish a guide, edited by Loring Schwarz and written by Charles Flink and Robert Searns, on greenway planning, design, implementation, and management to be released by Island Press (Washington, DC) and available in the spring of 1993.

Exotic Species

Local landscape architects generally know which plant species are exotic to the area and can be an excellent source of information on how to manage your greenway with native plants.

Elton, C. S. 1956. The Ecology of Invasions by Animals and Plants. London: Methuen.

Mooney, H. A. and J. A. Drake, eds. 1986. Ecology of biological invasions of North America and Hawaii. New York: Springer-Verlag.

People/Greenway Interactions

Stokes, S. N., A. E. Watson, G. P. Keller and J. T. Keller. 1989. Saving America's Countryside: A guide to rural conservation. Baltimore: Johns Hopkins University Press.

Proudman, R.D. and R. Rajala. 1984. AMC Field Guide to Trail Building and Maintenance. 2nd edition. Boston: American Mountaineering Club.

Conclusion

Greenways offer conservationists an opportunity to translate public support for locally oriented land protection into long-term ecological gain in a feasible and cost-effective way. While applying the concept of ecological functioning to greenway design and management helps us to fulfill their potential as protected areas, it should also teach us that greenways alone are not enough. Just as different parts of the landscape fulfill different ecological roles, greenways have different ecological potentials from other types of protected land.

By the same token, a greenway may not always be beneficial. Greenways, especially those designed to connect existing protected areas, require careful scrutiny to ensure that they do not promote unwanted movement, such as exotic species or fire, between nature reserves. Greenways should protect natural linkages in the landscape, not create artificial ones. It is essential that, whenever possible, greenway projects be preceded by thorough studies of the landscape.

As the vitality of Britain's hedgerows suggests, letting nature reign, even in narrow strips of land, can be greatly beneficial to a landscape. While the primary goal of land conservation remains protecting native ecosystems at a scale which will ensure their long-term survival, every little bit of green space is important. Considering greenways in an ecological light indicates that relatively little land, when designed and managed with regard to natural process, can produce a lot of environmental return.

In producing environmental return, greenways can also provide economic benefit. Another publication by the National Park Service, *Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors*, goes into great depth on how greenways bring business into a community and provide natural alternatives to expensive projects such as water filtration and flood control. We hope that these two publications will help increase understanding and appreciation of greenways and foster support, enthusiasm, and an ever-expanding network of these wonderful places.