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Minimizing Conflict between Recreation and Nature Conservation

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Most greenways are created with multiple goals in mind. Two of the foremost are providing recreational opportunities and conserving nature. Although these two goals frequently enhance each other, sometimes pursuing both simultaneously can result in conflicts. In some cases, recreational use can so severely degrade an area that not only is the environment damaged but the quality of the recreational experience itself is diminished.

This chapter explores various ways of reducing the conflict between recreational use and nature conservation. The chapter begins with an overview of the impacts of recreation on natural environments and the factors that influence the severity of these impacts. These factors-whether characteristics of recreational use or of the environment--suggest a number of alternative design strategies for managing impacts. A case study illustrates how a range of design and management strategies have been adapted to a specific situation. Finally, practical guidelines for design and management of greenways are proposed.

Ecological Impacts of Recreation

Greenways are used for a variety of recreational activities. Most greenways support nonconsumptive activities such as walking, jogging, picnicking, nature study, and photography, others permit consumptive uses such as fishing and hunting. Some are used for specialized recreational activities, like rock climbing, bicycling, and horseback riding. Each of these uses has a slightly different impact on the environment, which in turn calls for different design or management practices.

For the sake of clarity the following discussion is divided into sections corresponding to the four major landscape components that are affected by recreation: soil, vegetation, wildlife, and water. Important linkages, however, exist between each of these components and should not be overlooked. For example, if hikers trample an area and the soil becomes compacted, plant growth may decline because of less favorable growing conditions, erosion may be accelerated due to the sparser vegetative cover, eroding sediments may increase the siltation of nearby water courses, and the silty water may reduce stream quality for fish habitat. A single recreational activity can set in motion events that can cause impacts to all four of the major components of the landscape.

Clearly, impacts are not isolated occurrences. Instead, they occur in combination and can exacerbate or compensate for each other. Therefore, it is important for designers and managers to look comprehensively at ecosystems and at their design and management programs rather than to focus narrowly on individual places, recreational activities, or types of impact.

Impacts on Soils

Trampling by humans causes most of the impact that recreation has on soils and vegetation (Fig 5.1; Figure 5.2). Although all five of the typical components of soil-mineral matter, air, water, dead organic matter, and living organism-e disturbed by trampling, it is the impact on the latter four that is most detrimenta! to the various forms of life that the soil supports.

Most of the dead organic material in soil is concentrated in the upper layers, particularly in a surface layer that usually consists primarily of organic matter. This layer, called the organic horizon, is critical to the health of a soil because of the important role it plays in the soil's biological activity. The organic horizon also promotes good water relations by increasing the absorptive capacity of the soil, decreasing runoff, and increasing moisture retention. It is a source of nutrients critical to plant growth and can effectively cushion underlying mineral soil horizons, which are more vulnerable to the compacting and eroding effects of rainfall and recreation. Organic horizons are generally less vulnerable to erosion than mineral soil, but if organic matter is pulverized by trampling, they too can be eroded away, exposing the mineral soil beneath.

When trampling compacts the mineral soil, which lacks the physical resiliency of organic matter, particles are squeezed together tightly, drastically reducing the amount of pore space between particles. The larger pores-those that promote good soil drainage and are normally occupied by air-can be nearly eliminated (Monti and Mackintosh 1979). Their elimination can reduce aeration and water availability and make it difficult for plant roots to penetrate the soil. These changes can reduce both germination success and the vigor of established plants and can be detrimental to soil-dwelling organisms. The loss of soil-dwelling biota can cause further impacts on soil and vegetation because these organisms are important agents in promoting the development of soil structure and are criti-

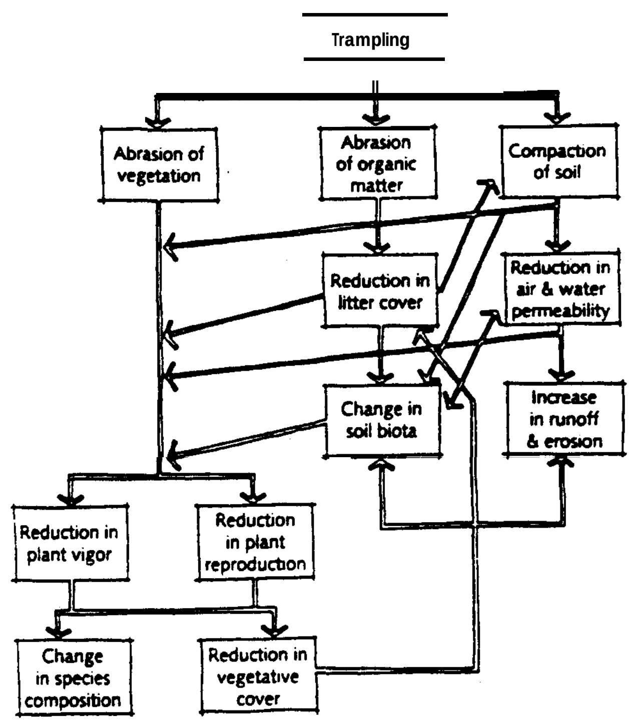


Figure 5.1 A conceptual model of trampling effects on vegetation and soil. (Based partly on Liddle 1975 and Manning 1979.)

Figure 5.2 An example of vegetation loss and soil erosion caused by trampling along a trail ascending the banks of the Verde River. Arizona. Photo by D. Smith.) (picture deleted due to poor reproduction)

cal to the process of nutrient cycling. In addition, compacted soils lose much of their infiltration capacity, leading to an increase in surface runoff following rains or other precipitation. This runoff often results in increased soil erosion wherever soils have been compacted, on trails, at picnic sites, at vista points, and along river banks. Soil compaction is reversed, however, by the effects of biotic and frost action in the soil.

Impacts on Vegetation

Recreation's impacts on vegetation are generally more obvious than impacts on soils. Places that receive heavy recreational use often become crisscrossed by informal trail networks, and in the process, large areas may become completely devoid of vegetation. Damage can also result when shrubs and trees are cut for firewood, to make tent poles, or to create clearings. Hack marks and initials are frequently found on woody vegetation, and sometimes recreationists cut vegetation for no apparent reason.

Trampling can crush, bruise, shear off, and uproot vegetation. Plants in trampled places may have reduced height, stem length, leaf area, flower and seed production, and carbohydrate reserves (Liddle 1975; Speight 1973). All of these changes lead to reduced vigor and less successful reproduction. Sometimes they lead to a plant's death. Consequently, vegetation in trampled places generally has less biomass, sparser cover, different structure (generally shorter stature), and different species than in undisturbed places.

Species differ in their tolerance of trampling, and these differences are reflected in the mix of plant species-the floristic composition-found in an area. Tolerant species are apt to thrive with increased recreational use because they face reduced competition from intolerant species that are weakened or killed by trampling. Also favored are those plants that can take advantage of the changes in microclimate--such as increased light and temperature--that result from trampling (Liddle and Moore 1974; Dale and Weaver 1974). Some species may be injured by trampling but survive nonetheless because they have adaptive characteristics, such as flexible stems or leaves.

Recreation sometimes plays a role in the introduction of exotic species, some of which have had serious impacts in areas of North America. Seeds of exotic species can be carried into greenways by recreationists, dogs, horses, or straying livestock, or they can be introduced by birds, water, or wind. Once in an area disturbed by recreation, exotic species often thrive because they favor the environmental conditions found there. The significance of this problem depends on the importance placed on maintaining strictly natural conditions as well as on the competitiveness of the exotic species. As Reed Noss notes in chapter 3, narrow greenways with abundant edge habitat are particularly vulnerable to invasion by exotics.

Although some of the impacts of trampling on vegetation are inevitable with recreational use, the felling and mutilation of large shrubs and trees is largely needless. Most damage to these plants is caused by activities that are either malicious (e.g., hacking tree trunk) or unnecessary (e.g., cutting trees for firewood). A substantial amount of impact to vegetation also occurs in the construction of recreational facilities, such as the creation of trails and picnic areas.

The conceptual model in Figure 5.1 summarizes the various ways in which trampling affects soils and vegetation. As the figure shows, significant reciprocal and-cyclic relationships exist between soil and vegetation impacts. For example, reductions in litter cover make the soil more susceptible to erosion; with increased erosion, more litter cover is lost, which increases susceptibility to erosion and so on. A particularly important cyclic relationship involves vegetation, litter cover, and soil biota. As vegetative cover diminishes, a prime source of organic litter is lost. With diminished inputs of organic matter to the soil, the density of soil biota declines. Changes in soil biota reduce the availability of numerous to plants, which in turn can cause further loss of vegetation. Once this sequence is under way, many of the damaged components will need to be repaired before the system can be restored.

An important characteristic of both soil and vegetation Impacts is their highly concentrated nature. Most Impact is confined to the specific place where recreation occurs, such as around recreational facilities and along connecting travel paths (Manning 1979). A few yards from totally denuded and eroded trails or vista points, soils and vegetation may be completely unaffected by recreational use (McEwen and Tocher 1976). As will be discussed later, designers and managers can use this fact to their advantage in planning for recreational use and impact.

Impacts on Animals

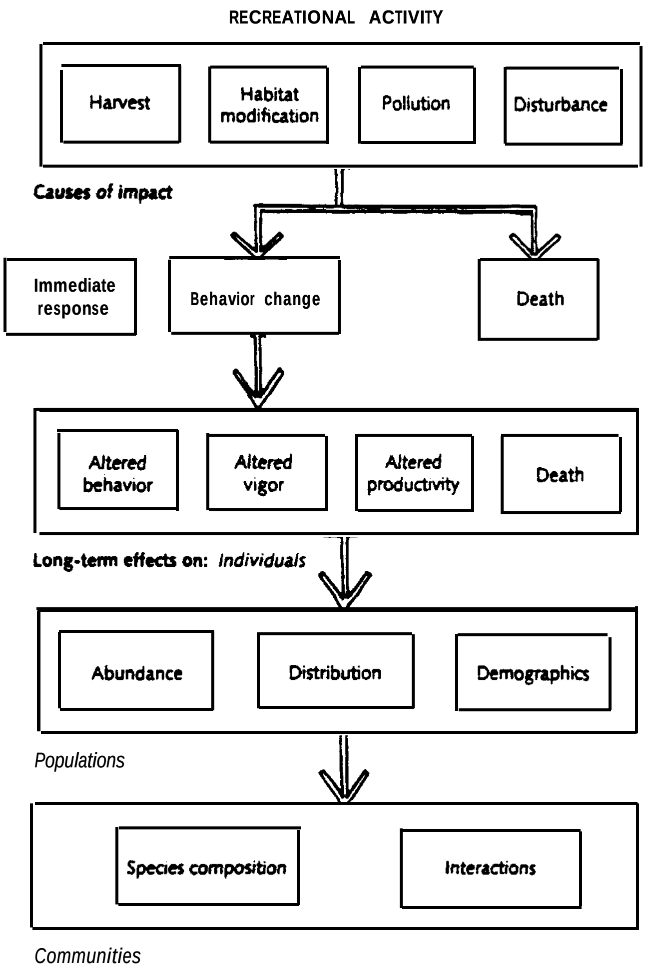
Because animals disturbed at one place can remember the experience and respond differently as they move to other locations, recreational impacts on animals can have more far-reaching effects than those on plants. Moreover, because animals are capable of teaching their offspring, reactions to disturbance can be passed from generation to generation. In contrast to vegetation impacts, impacts on animals are not usually obvious to people, they are difficult to study, and they are poorly understood.

As the conceptual model in Figure 5.3 outlines, there arc four general ways in which recreational activities can affect wild animals: harvest, habitat modification, pollution, and direct disturbance:

1. Animals can be harvested through hunting or fishing.
2. Their habitats can be modified, either intentionally or unintentionally. Creating trails, for instance, can have pronounced impacts on populations of small mammals, bids, reptiles, amphibians, and invertebrates in localized areas.
3. Animals can suffer from pollutants, litter or food, left by recreationists. Discarded plastic six-pack rings or fishing line, for instance, can entangle birds. Less obvious, but more common, is the disturbance that results when animals are fed by recreationists or when animals eat food or garbage left behind. The significance of this problem is hard to assess. It has certainly been detrimental to bears in national parks. As bears become habituated to human foods, contact between bears and humans increases, and the bears often must be destroyed to avoid dangerous encounters.
4. Direct disturbance may result when recreationists come too close to animals. This disturbance, sometimes called harassment although it is usually unintentional, is probably the primary means by which recreationists affect larger vertebrates-birds and mammals. It can reduce the effective size and habitat quality of an area and even destroy a greenway's value as a migration corridor. The significance of harassment varies from place to place and from species to species. Unfortunately, our understanding of the problem is limited.

Although an animal may respond to recreational disturbance by changing its behavior and thereby reducing or avoiding the disturbance, the animal may be

Figure 5.3 A conceptual model of the Impacts of recreational use on animals.



unable to do so; if the disturbance is severe enough, the animal may not survive. Of course, death is the intended result of hunting and other forms of harvesting. But nonconsumptive activities can also kill animals, although such impacts arc generally localized and confined to small, inconspicuous animals such as invertebrates. Consequently, these impacts are often ignored.

Behavioral changes by animals can be a serious concern in greenway design and management, as the following examples show:

- Habitat modification can cause valued bird species to seek out alternative places to nest.
- Improper disposal of food and garbage may increase the populations of generalist species-those that are capable of capitalizing on human food sources and of crowding out species of greater ecological significance.
- Unintentional harassment by recreationists can lead to diverse behavioral responses such as interruption of feeding by bald eagles, abandonment of nests by golden plovers, increased heart rates in bighorn sheep, and flight of elk and moose.

Many of these immediate responses to disturbance are short term. For example, deer typically return within hours to areas they have left after being disturbed by snowmobiles (Dorrance et al. 1975). Even short-term effects, however, can have a major impact on animals living in stressful conditions, like deer trying to survive in deep snow and cold. Unfortunately, we know little about the long-term effects of recreational disturbance on the energy balance or survival rate of individuals or on entire populations and communities of wildlife.

Reed Noss has noted in chapter 3 that greenways should ideally function both as habitat and as conduits for movement. The long-term impacts that might reduce the habitat value of greenways include (1) the displacement from an area of individuals or entire pop ulations of wildlife species, (2) decreased productivity due to disturbance of birthing sites, and (3) the loss of native species displaced by disturbance loving species

Abandoning disturbed places in favor of undisturbed places has been documented for a number of large mammals, including caribou and bighorn sheep (Geist 1978). Sensitive bird species may be displaced in a similar manner.

Birds have been the focus of most of the work showing decreased productivity due to disturbance from recreation. For example, in the Boundary Waters Canoe Area in Minnesota, loons experiencing fewer human contacts produced significantly more surviving young (Titus and Van Druff 1981). In Illinois, generalist bird species, such as blue jay, robin, and cowbird, were attracted to a nature trail in a forested area, where through competition, predation, and nest parasitism they may displace forest-interior, area-sensitive species, like veery and scarlet tanager (Hickman 1990)

There is little available evidence that recreational use interferes with the utility of a greenway as a conduit for animal movement. There are a number of situations, however, where interference is likely to occur. For example, even low levels of recreational use can reduce the movement in greenways of large, wide-ranging mammals, like bear and mountain lion, that are intolerant of people. Greenways that receive heavy recreational use and that are invaded by exotic plants may no longer provide suitable habitats for migrating birds or smaller mammals. Clearly, there is much to learn about the impacts of recreation on animal populations, their habitats, and their movements.

Impacts on Water

The effects of recreational use on water are also poorly understood. A number of studies have examined the impacts on water of motorboating, shoreline housing developments, and sewage disposal. However, little study has been made of the effects on water of the nonmotorized, casual types of recreation typical of most greenways.

In wild settings where camping is common, contamination of drinking water by human waste is a pressing concern, as are the increased nutrient inputs that may result (Ring and Mace 1974). For example, an exceptionally high level of phosphorus was recorded at a semiwilderness lake in Canada that had experienced a twentyfold increase in recreational use (Dickman and Dorais 1977). Some greenways such as those in developed landscapes may receive enough contamination from other upstream sources that local recreational impact is rendered inconsequential.

The most significant effects of recreation on water. however, are likely to occur indirectly, through disturbance of soils and vegetation. As discussed earlier. recreational USC tends to lead to the loss of vegetative cover and soil organic horizons and contributes to the compaction of mineral soils. These impacts result in increased overland runoff, erosion, and deposition of sediments in waterways. Unfortunately, these impacts tend to be exacerbated by the attraction of recreationists to water. Because of heavy use, vegetation loss and toil erosion on trails and in trampled areas are often most severe along the banks of watercourses-the very Places where these impacts are most harmful. Soil impacts can reduce the overall filtration and erosion-control functions of greenways. The tendency for the height, cover, and diversity of vegetation to be reduced by recreational use also limits the capability of vegetation to buffer water temperatures and to provide habitat and food for animals.

Factors That Influence the Amount of impact

Some degree of environmental impact is inevitable wherever recreation occurs. Since it is rarely desirable to preclude all opportunities for recreational use, the challenge for the designer or manager is to keep recreational impacts within acceptable limits. Strategies for minimizing impact become clearer with an understanding of the factors that influence the amount of impact. For example, if motorcycles are damaging an area, then an obvious strategy is to restrict such use. But if disturbance is occurring in an especially fragile site, then the strategy should probably be to exclude all recreational use of that site regardless of the type of recreation. Thus, design and management efforts should be focused on those factors that have the greatest potential to affect a site.

Recreational impact occurs when there is interac - tion between recreational users and an environment that is vulnerable to disturbance. Therefore, the amount of impact is a function of both use and environmental characteristics. The amount is also influenced by the design of the site and the intensity of management. (For example, the inherent vulnerability of a site can be reduced by paving a trail.)

Use Characteristics

Many characteristics of recreation determine its impact on an environment. The most significant are (1) the amount of use, (2) the type of recreational activity, (3) the behavior of recreationists, (4) the spatial distribution of use, and (5) the temporal distribution of use.

The relationship between the amount of use and the resulting amount of impact has been studied intensively. Most studies report that this relationship is asymptotic; that is, differences in the amount of use influence the amount of impact most when levels of use are relatively low (Figure 5.4). (The difference in impact between an unused and a lightly used place will tend to be greater than the difference between a place that is heavily used and one that is very heavily used.) Accordingly, the amount of impact increases rapidly with initial increases in the amount of use; at higher use levels, however, large increases in use may result in very small increases in impact. For example, once trampling exceeds relatively low threshold levels, vegetation loss and soil compaction are pronounced regardless of the amount of use (Cole 1987a). Similarly, a study of the effects of cross-country skiers on moose and elk in a park in central Alberta found that although the animals moved away from trails with the onset of skiing, they did not move any additional distance as the number of skiers increased (Ferguson and Keith 1982).

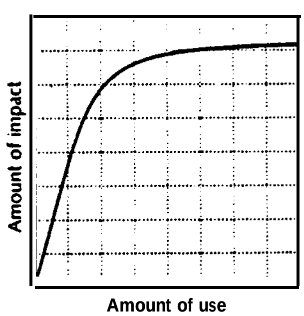


Figure 5.4 A generalized model of the asymptotic relationship between the amount of use and the amount of impact Where use levels are low, incremental increases in Uk amount of use have a pronounced effect on the amount of impact Where use levels are moderate to high, incremental incremental in the amount of use have little effect on the amount of impact

The implications of these studies are profound because they support the strategy of minimizing impact by concentrating use as much as possible. Increasing use levels in places that are already heavily used will probably have few negative effects; however, minimizing use levels in undisturbed places may have tremendous positive effects. When allocating land for greenways, it is imperative to define the boundaries so that the greenway is wide enough to accommodate both high-impact corridors as well as zones that are virtually undisturbed. Then it is incumbent upon greenway managers to see that undisturbed zones remain that way.

Impacts can differ greatly with the type of recreational activity. For example, consider the obvious difference in impact that hunting and photography have on animals. In a controlled experiment on a grassland in Montana (with a 15-degree slope), 200 passes by a motorcycle removed twice as much vegetation as the same number of passes by a horse and 9 times as much vegetation as 200 hikers (Weaver and Dale 1978). Although there are exceptions, motorized uses will usually cause more impact than nonmotorized uses. horses will cause more impact than hikers, and overnight users will cause more impact than day users.

The behavior of recreationists, whether alone or in groups, is also highly significant in determining the impacts of recreation. A disproportionate amount of the total impact received by an area comes from people who engage in malicious acts or vandalism, although they may be unaware of the full effects of their activities. The felling of trees is an obvious problem. More subtle and pervasive are the impacts caused through ignorance, for example, nest abandonment caused by bird-watchers getting too close to nesting birds. People with dogs usually disturb wildlife more than those without, particularly if the dogs are unleashed (MacArthur et al. 1982).

The way recreational use is distributed spatially influences both the overall amount and the distribution of the resulting impacts. Concentrated use-the norm in many greenways-results in pronounced disturbance of a few places with little impact elsewhere (McEwen and Tocher 1976). Where use is widely dispersed, more of an area is disturbed. Unless use levels are quite low, dispersal may not dilute impacts; it may merely result in more widespread damage. This conclusion follows from the research findings, mentioned previously, about the asymptotic relationship between the amount of use and the amount of impact. Concentrating use may be particularly effective in greenways because they are often narrow. Only by concentrating use will it be possible to maintain other portions of the greenway in a near-natural condition.

The way recreational use is distributed over time is the final influential use characteristic to be discussed here. Soils, for example, are particularly vulnerable to impact during the times of the year when they are water saturated. Hikers attempting to get around seasonally boggy places on trails can create wide mud holes and multiple trails that disrupt drainage. Also, some animals are particularly vulnerable to disturbance at certain times of the year, such as when they are nesting or stressed by winter conditions, or at certain times of the day, such as at the time when animals are accustomed to visiting water sources to drink

Environmental Characteristics

The amount of impact an area receives is also influenced by the inherent vulnerability of the soils, vegetation, animals, and water in the area and by its topographic characteristics. For example, in trampling experiments, 40 passes by hikers in a year eliminated half of the vegetation under a closed-canopy forest, whereas 10 times as much us-400 passes per year-was needed to eliminate half the vegetation in an open grassland (Cole 1987a).

Although there are no absolute rules regarding these issues, most studies have found that mature trees and grasslike plants are usually resistant to trampling, whereas mosses are neither highly resistant nor highly sensitive. Shrubs vary from being quite resistant to moderately sensitive, forbs vary from moderately resistant to highly sensitive, and lichens and tree seedlings are generally quite sensitive (Cole 1987b). Although these broad categories are useful as general indicators, the vulnerability of specific vegetation needs to be assessed site by site.

The likely resistance of vegetation can also be predicted by evaluating the morphological and physiological characteristics of plants. Characteristics that individually or in combination make a plant tolerant of trampling include (1) being either very small or very large, (2) growing either flat along the ground or in dense tufts, and (3) having leaves and stems that are tough or flexible. Characteristics that make a plant susceptible to damage include (1) growing to a moderate stature, (2) having an erect growth form, and (3) having woody, brittle, or delicate stems and leaves Figure 5.5). Since most plant associations are ma& up of both tolerant and vulnerable species, trampling effects can be decreased by locating trails and other improvements in places that have a preponderance of tolerant species.

The vulnerability of soils varies with a large number of factors, including characteristics both of the soil itself and of the site. Some broad generalizations about relationships between soil properties and vulnerability are listed in Table 5.1. In most cases, vulnerability is lowest when the soil properties listed in the table are at

Figure 5.5 Plants that are (a) tufted and wiry or (b) prostrate and matted are generally resistant to trampling damage; plank with (c) erect herbaceous and leafy stems or (d) brittle woody stems are generally sensitive

Table 5.1 Relationships between soil characteristics and site vulnerability

Soil Property	Level of Vulnerability Low	Moderate	High
Texture	Medium *(loam)*	Coarse *(sand)*	Fine *(clay)*
Organic content	*Moderate*	Low	High
Soil moisture	Moderate	Low	High
Fertility	Moderate	High	Low
Soil depth	None	Deep	Shallow

moderate levels. For instance, soils with low moisture levels are unable to support dense vegetation and are therefore susceptible to erosion. Soils with high levels of soil moisture, however, are even more fragile, because they are readily deformed when subjected to stress. Water-saturated soils quickly degenerate into quagmires when trampled. In most cases, soils with moderate moisture levels have the lowest vulnerability to recreational impact.

The vulnerability of wild animals is complex and poorly understood. Much of the complexity results, as mentioned earlier, from the ability of animals to learn from experience and thereby adapt to recreational disturbance. Several studies suggest that animals subjected to predictable, nonthreatening disturbances can become habituated to and tolerant of those disturbances. For example, mountain goats in Glacier National Park have learned to tolerate frequent contact with park visitors (Singer 1978). Conversely, animals are likely to respond to frequent and predictable negative encounters by avoiding them, as has been demonstrated in comparisons of hunted and nonhunted wildlife populations (King and Workman 1986). Since this behavior is largely learned, two individuals of the same species may differ greatly in their vulnerability to the same disturbance. These differences make anticipating impacts on wildlife all the more challenging.

The vulnerability of water to pollutants (such as sediments and nutrients) from recreational activities is likely to be determined by characteristics of both the water and the surrounding land. If the surrounding land has vegetation, soils, and topography that make it highly vulnerable to erosion, then erosion is likely to result and water quality to decline. If, for instance, a trail is constructed along a stream on steep slopes with highly erodible soils, then a considerable amount of sediment will probably find its way into the water. Thus, adjacent land-use practices can have a major impact on vulnerability.

Waterways are more susceptible to contamination if they are not frequently flushed out by large quantities of water and if they lack chemical properties capable of buffering pollutants. Thus, small water bodies and streams with low flows have a greater vulnerability than larger ones with higher flows.

Topographic characteristics influence the likelihood that facilities, such as trails, will deteriorate. For example, a trail's potential for erosion is influenced by the degree of slope of the trail, both along and across it, and by the trail's position (whether the trail is close to the top or to the bottom of the slope). Trails that run uphill readily channel water and are more subject to erosion than trails oriented perpendicular to the slope (Bratton et al. 1979). Trails located high on slopes have smaller areas draining into them and are therefore less likely to erode than trails located lower on slopes.

It is dangerous to draw sweeping generalizations about the relative vulnerability of landscapes. There will almost always be certain characteristics that make one environment more vulnerable than another and other characteristics that make it less vulnerable. The greenway designer has the difficult job of carefully evaluating the vulnerability of many critical parameters, deciding on the relative importance of each, and basing an ultimate evaluation of vulnerability on this analysis.

Design Strategies and Practical Tools

Many of the factors that influence the extent and intensity of an impact can be manipulated to reduce that

Table 5.2 **Factors that influence recreational impacts and management strategies and examples of tools for minimizing impacts.**

Factor	**Strategy**	**Tool**
Use characteristics		
Amount of use	Limit amount of use	Limit number of entrants Limit size of parking lot
Type of activity	Limit destructive activities	Prohibit certain activities Zone by activity type
Visitor behavior	Influence behaviors	Low-impact education Prohibit certain behavior
Use distribution		
Spatial	Concentrate use	Concentrate use at facilities such as trails
Temporal	Control timing of use	Close areas at certain times
Vulnerability	Control location of use	Locate facilities on durable sites Close fragile areas
	Harden sites	surface trails
	Shield the site from use	Bridge vulnerable places Install toilets

impact. For example, how use is distributed spatially can be changed by rerouting trails or changing access points. Or the inherent vulnerability of a site can be decreased through management intervention. Thus strategies for minimizing impact should respond to the combination of use and environmental characteristics that determine the type and level of impacts in an area. This section explores such strategies and some practical tools for controlling impacts on greenways (Table 5.2).

Understanding Use Characteristics

In most situations, limiting the amount of recreational use an area receives is the simplest strategy for reducing recreational impacts. As mentioned earlier, this strategy will be most useful in places that are not heavily used or disturbed. In places that are already highly used and disturbed, limiting use by itself may have little effect on impact levels. Even where there is a need to limit use, there are often more subtle options besides placing a strict quota on the number of visitors. Parking can be restricted to established lots, and the number of parking spaces can be limited. The location of access points, the types of facilities that are provided, and the amount of advertising that the area receives can all be controlled to limit use. These subtle means of influencing both the amount and distribution of use can be key to managing greenways without resorting to strict regulations.

Prohibiting or limiting specific activities that are particularly destructive can be another effective strategy. Using motorized vehicles, bicycling, horseback riding, hunting, and walking dogs can all be particularly destructive and in many locations have been prohibited. Sometimes it is possible to implement a zoning strategy in which these uses are allowed in carefully selected areas of the greenway and prohibited elsewhere (Figure 5.6). This strategy of concentrating use is discussed later. Barriers may be needed to exclude or limit certain activities, such as off-road vehicle use. But, it also may be possible to discourage some of these activities in subtle ways. For example, if horse-unloading ramps are not provided, some riders will decide not to use an area.

Figure 5.6 Horses are excluded from the floodplain of the Verde River in Arizona because of the fragile nature of the floodplain and its banks. (Photo by D. Smith.) **Picture deleted due to poor reproduction.**

Influencing behavior through education and interpreration is one of the strategies with the greatest potential for long-term success. Certain types of impacts, like hacking of trees, can sometimes be eliminated completely by educating recreationists. Other impacts, such as trampling of vegetation, cannot be totally eliminated but can be reduced if there are shifts in people's behavior. Many conservation agencies have produced signs, displays, videotapes, brochures, and even radio and television spots that are designed to teach recreationists how to minimize their impact on the land (Martin and Taylor 1981; Hampton and Cole 1988).

There are several key points to remember in utilizing education and interpretation: (1) make people aware of the link between inappropriate behavior and specific ecological problems, (2) clearly demonstrate appropriate ways for visitors to behave so that problems can be avoided, and (3) encourage a sense of commitment in people to do something about these problems. Traditional methods of persuasive communication include trailhead bulletin boards and brochures explaining to recreationists how to reduce their impacts. Messages about reducing impacts can also be included in interpretive displays along greenways. For example, a display on nesting birds could include a message about the importance of visitors' not getting too close to nesting sites because of the serious consequences of nest abandonment.

Controlling the spatial distribution of recreational use is usually attempted by confining recreationists to trails and other facilities. Two points are crucial: (1) people should be encouraged to stay on planned traffic routes and at activity centers, and (2) these facilities should be located on durable sites. To convince people to use trails, paths must lead where people want to go, and people have to be aware that the trails do so.

Controlling where people go in a greenway requires knowledge about what motivates them, what kinds of behavior are compatible with a particular setting, what an appropriate trail surface is, and how to design and locate signs when destinations cannot be seen from the start of a trail. One technique to use before going to the expense of trail development is first to observe how recreationists use an area, including the informal trail network they develop, and then to design the formal trail system based on the observations.

A common problem is that people often take shortcuts at trail switchbacks, causing unsightly, easily eroded paths. Although shortcutting can be reduced by prohibiting it and by educating people about the problems it creates, the ultimate solution is to make it inconvenient to shortcut the trail or at least to make it appear so (Figure 5.7). This solution can be achieved

Figure 5.7 Properly designed switchbacks that run perpendicular to the direction of water flow are an effective way of preventing trail erosion on steep slopes. (courtesy of Appalachian Mountain club.) Picture deleted due to poor reproduction.

by varying the layout of switchbacks, hiding the view of one switchback from another, maintaining a steep grade between switchbacks, and using barriers such as rock outcrops, brush, or boulders.

Barriers arc also an effective means of keeping people on surfaces designed for recreational use. The word *barrier* usually brings to mind something obtrusive like a fence, and such a strong barrier may be needed in certain places. More often, however, barriers of native materials, such as large rocks or logs, can be used to define the edges of trails, parking lots, or other areas. In the case of a trail, something as subtle as dense undergrowth may keep people from straying from the tread way. More obtrusive are the scree walls built along the high-altitude trails in the White Mountains in northern New Hampshire. The walls keep people from trampling the adjacent alpine vegetation.

Controlling when all or selected parts of a greenway may be used can be an especially important strategy for minimizing impact on wildlife and soils. Areas can be closed during certain seasons when wildlife are particularly vulnerable, such as when birds are nesting. Also, use can be limited during seasons when soils are water saturated and prone to disturbance. For example. the Long Trail in the Green Mountains in Vermont is closed during the spring mud season, when melting snow saturates high-altitude organic soils. Such strategies can be implemented through regulations, educational and interpretive programs, or a combination of both. Strategies range from prohibiting use and fining violators to attempting to persuade recreationists to avoid certain places at critical times. In Vermont, television stations have broadcast public service announcements explaining the seasonal closing of the Long Trail.

Reducing Site Vulnerability

Site vulnerability can be reduced by locating greenway facilities in more durable areas. Careful attention to the location of trails and other improvements will reduce costs associated with overcoming site limitations or with remedial measures that become necessary after damage occurs. For example, for the masons discussed earlier, trails should avoid places with wet soils and steep slopes. Wet soils can be bridged, and steep slopes can be negotiated by using switchbacks and drainage devices, but these are costly solutions that require ongoing maintenance.

The location of ecologically sensitive and valuable places also needs to be considered when locating facilities. Sensitive areas that are not especially attractive to recreationists should simply be bypassed. Sensitive areas, such as stream banks or alpine meadows, that attract recreationists are more problematic. Recreational disturbance can be minimized at these sites by limiting access to spur trails (Figure 5.8) so that only those willing to make the extra effort required to get

Figure 5.8 Since most people will stay on the main trail. limiting access to sensitive areas to a spur trail may reduce the number of visitors to the sensitive area

there will go to these special places. The majority of people will stay on the main trail and bypass the sensitive site. Ideally, providing a well-defined system of trails and other improvements is all that is needed to keep visitors away from sensitive areas. In some cases, however, it may be necessary to close highly sensitive areas that would be damaged by even slight use.

A second strategy to deal with sensitive areas is to place natural mulching materials such as wood chips, gravel, and crushed rock on the surface of trails and other places that receive concentrated trampling. In places with very heavy use the surface may have to be paved with asphalt or concrete.

When surfacing trails, it is important to allow for proper drainage of any runoff in such a way that natural drainage systems are not disrupted and erosion is not increased. For this reason permeable materials, such as wood mulch, are often the best choice because they allow water to drain into the soil below. Constructing water bars (Figure 5.9) and other drainage devices or more elaborate systems of ditches and culverts can also help remove water from trails before it gathers enough force to cause significant erosion.

A third option is to shield the site from use by physically separating people from vulnerable elements. Bridges over standing water and elevated walkways over wet soils are good examples of shielding (Figure 5.10). The. actual vulnerability of the soil is not

Figure 5.9 Water bars are simple devices commonly used to divert water off the trail surface which Is highly erodible. (Courtesy of Appalachian Mountain Club.)

changed, but the amount of impact is reduced because the soils, are no longer being trampled Providing toilets or outhouses so that human waste is kept to one place and away from water is another way of separating users from the environment. This strategy can be very effective, especially where use is heavy. However, it has several potential drawbacks. Where naturalness is a management objective, a structure such as a toilet may be seen as an intrusion on visitors' recreational experience. The shielding approach also has a high initial cost and usually requires periodic maintenance. On the other hand, this strategy can result in a more comfortable experience for the recreationist and can be a very effective way to protect resources.

Treating Symptoms

A final strategy, rehabilitating sites, involves treating symptoms rather than changing or eliminating root causes. Problems are only addressed once they appear and are in need of attention. This strategy is reactive management rather than proactive design. For example, picnic sites that have lost their vegetation and are eroding can be closed to use, soil can be brought in, and new vegetation can be planted. This solution might be effective in the short term, but if the site is ever opened to use again, the same problems arc likely to reappear. Rehabilitation is most effective when used in concert with actions designed to attack the underlying causes of problems.

Combining Strategies

These design and management strategies and tools range from those that are highly regulatory and restrictive to those that are subtle and do little to hamper the recreationist. Where recreational use is heavy and produces considerable impact on highly valued resources, there may be little alternative but to restrict use. For instance, if the overriding goal of a greenway is to preserve nature, it may be necessary to tightly restrict or perhaps even prohibit recreational use. Where more subtle techniques are likely to be effective, they are preferable because they are less restrictive of the freedom and spontaneity that is important to people's enjoyment of nature.

Although the preceding strategies and tools were discussed one by one, that is not the best way to apply them. There are usually several possible approaches for dealing with a specific problem, and the likelihood of success will increase if a combination of approaches is

Figure 5.10 This elevated walkway separates hikers from the boggy soils underneath. (Photo by D. Cole.)

adopted. A range of potential solutions should be evaluated, and a suite of the most promising should be tried.

Balancing Recreation and Conservation at Craggy Pinnacle

A good example of how these strategies can be adapted to specific situations is the design for Craggy Pinnacle along the Blue Ridge Parkway in North Carolina. Craggy Pinnacle offers some of the finest views and rhododendron displays in the southern Appalachian Mountains (Figure 5.11). Visitors hike a half-mile-long trail to the summit where they can enjoy panoramic vistas that arc framed by the numerous rock outcrops that encircle the peak. These rock outcrops enhance visitor experiences by offering extensive views, privacy, flat ledges for informal seating, and intriguing places to explore (Johnson 1989a). They also harbor six rare or endangered plant species that account for nearly 90 percent of the vascular plant coverage on the rock outcrops. Uncontrolled visitor use of the area over the years has resulted in a system of informal trails that converge-along with the official trail-at the summit, where trampling of the rare flora is a serious problem.

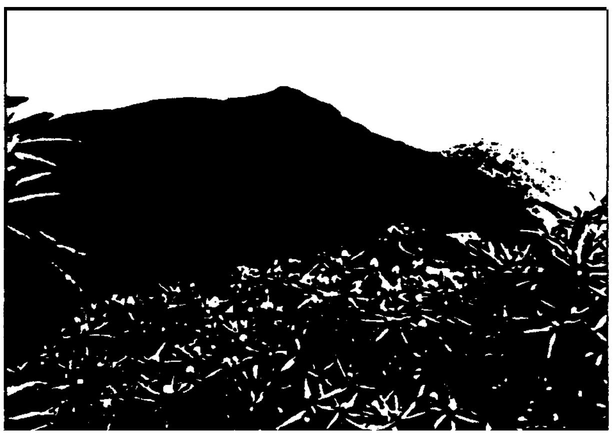


Figure 5.11 **(top) Craggy Pinnacle is easily reached from the Blue Ridge Parkway. (Courtesy of the National Park Service.) (bottom) With its rock outcrops, the summit is an almost irresistible spot for viewing the surrounding mountains. (Courtesy of Bart Johnson.)**

Confronted with the problems of informal trail development and damage of rare plants, researchers from the National Park Service carried out a trial management program in an attempt to solve these problems. They surveyed visitor use and the distribution of rare plants and assessed the microhabitat needs of the rare plants. Parkway administrators closed unofficial trails with brush and signs and monitored the effectiveness of the closures (Johnson 1989a).

They found that visitor use was as high as 484 people per day during the height of the fall foliage season and that as many as 50 percent of those users arrived at the summit by way of unofficial trails. Use at the peak was concentrated in an area ofjust 1000 square feet of which 750 are rock outcrops with rare plant habitat. The plant survey found conditions that ranged from areas that were relatively untrampled to completely decimated places where up to a foot of soil had been eroded, leaving bare rock exposed (Johnson 1989b).

Initial attempts to close trails with brush were not very successful. Over a two-month period, ten of the eleven brush barriers were either destroyed or rendered ineffective. In another attempt small signs that read "Fragile Habitat - Area Closed" were placed In front of the brush. The signs helped dramatically-only one brush barrier was rendered ineffective in two months, and the number of ineffective barriers increased to only three after the fall season. Managers concluded that

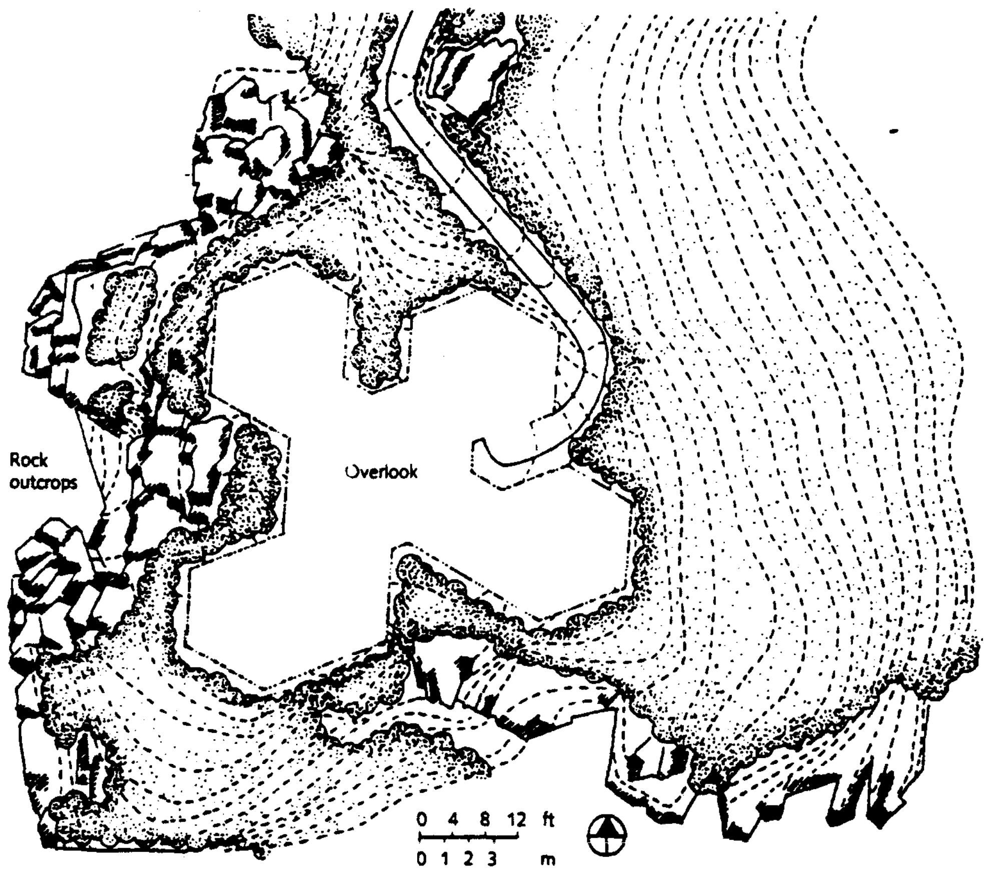


Figure 5.72 Design of an overlook for Craggy Pinnacle that will (1) concentrate use in a designated area, (2) protect rare plants from trampling, and (3) provide an attractive place for people to view the surrounding mountains. (Redrawn with permission from plan by Bart Johnson.)

the small interpretive signs were critical to keeping people on official trails, but that the signs and brush barriers were still only a partial solution to the problem (Johnson 1989c).

From observing visitor behavior came the idea for a larger overlook platform that will concentrate use, shield the rare plants from visitors, and retain most of the desired aesthetic attributes of the rock outcroppings. Once constructed, the stone-walled overlook will provide views and ledges to sit on (Figure 5.12). Alcoves in the overlook will give visitors a greater sense of privacy than before, as well as interesting nooks to explore. Interpretive displays will both enhance visitor enjoyment and, by explaining the fragility of the site, increase the likelihood that visitors will stay within the walls of the overlook while they are at the summit of Craggy Pinnacle (Johnson 1989a).

With visitor use better controlled and the underlying cause of the problem solved, the final step will be restoring the damaged plant communities. Experiments with propagating and reestablishing the rare plants are being conducted. In addition, the microhabitat assessment is helping to identify the habitat needs of each species, making it more likely that a self-sustaining community can eventually be reestablished (Johnson 1989b).

Craggy Pinnacle offers a number of important lessons for greenway design and management. This example shows how site research and experimentation can be used effectively to identify and respond to the specific underlying problems faced by an area. In this case, both visitor behavior and environmental conditions were analyzed to help identify the root cause of the problems. A variety of strategies are being used to deal with the conflicts: visitor use is being concentrated in a smaller space, vulnerable sites are being shielded from visitor use, certain areas are being closed with barriers, education and interpretation are being used to change destructive visitor behavior, and damaged sites are being rehabilitated. None of these techniques by itself would have the likelihood of success that this combination does.

Conclusions and Guidelines

Where greenways have the twin goals of providing recreational opportunities and preserving nature, managers are challenged to maximize the synergism that exists between these goals while minimizing the conflict. The key to the latter is to develop an understanding of both the recreational visitors and the environmental constraints. Successful recreation design and management avoid fighting against what people want to do; rather, they channel recreationists' desires in ways that will have less impact on the environment. Designers and managers may also have to increase the durability of sites to withstand use, and in some cases they may have to shield the site from intensive recreational use.

The following suggestions, organized by spatial scale, should help guide the design and management of greenways:

Selecting Alignments

1. Select places for recreation that offer settings and recreational opportunities that are scarce in the surrounding region so that unique recreational areas are protected.
2. Select places that offer a diversity of settings so that a variety of areas are protected.
3. Design networks of greenways so that there arc opportunities for both short and extended recreational visits.

Setting Widths

1. Set boundaries so that greenways are wide enough to provide both high-impact corridors of concentrated recreational use (if there is to be any recreation) and zones that are virtually undisturbed. This action will provide a balance between recreational opportunities and nature preservation by separating the potentially conflicting uses.
2. Increase greenway width as the sensitivity of the natural resources within them increases, as the importance of ecological values increases, and as the quantity and destructiveness of recreationists increase. Wider greenways provide greater opportunities for separating uses through zoning and for channeling use toward durable areas and away from sensitive places.

Preparing Site Designs and Management Plans

1. Locate and design facilities (trails, access points, picnic areas, visitor centers, etc.) to enhance recreational experiences as well as minimize environmental impact.
2. Concentrate visitor use on surfaces that separate users from the environment wherever levels of recreational use are high. Alternately, channel use to ground surfaces that are either inherently durable or that have been modified to be more durable.
3. Locate and design facilities to account for both the sensitivity of ecosystems and the type and amount of recreational use anticipated.
4. Use interpretation and education to reduce impact. Visitors should be made aware of (a) the value of sensitive natural resources, (b) the problems that certain types of behavior cause, and (c) how they can behave to minimize impact.
5. Use subtle means of encouraging appropriate behavior from visitors instead of restricting or eliminating access. Restrictions, closures, and law

enforcement, however, become more important with the increasing value and vulnerability of the resources needing protection:

6. Establish a system of zones-based on the capability of the landscape-that allows certain activities only in designated zones. These zones will provide a diversity of recreational activities while separating particularly destructive types of recreation from sensitive areas.
7. Discourage off-trail use by (a) creating, when appropriate, trails that go where people want to go, (b) making certain that people know the trail goes there, and (c) providing a well-defined trail of adequate width with an appropriate surface for walking. Maintaining dense vegetation, placing logs and rocks along a trail, and routing a trail through rough terrain can all help to keep people on a trail. Fences and signs should be used as last resorts.
8. Avoid wet soils and steep slopes when routing trails. Where wet soils are unavoidable, they should be bridged, taking care not to disrupt the natural drainage. Erosion of short steep stretches of trail can be minimized by using steps or strategically placed water bars. Longer stretches should incorporate carefully designed switchbacks. Damage to switchbacks will be minimized if they have tight turns and are well drained and if shortcutting is discouraged by placing the turn in heavy forest or by taking advantage of rock outcrops, cliffs, and boulders.
9. If heavily used trails are to be surfaced, choose a material based on user requirements, aesthetic considerations, impact potential, and the cost of construction and maintenance. Permeable surfaces should be used when possible because they function similarly to the natural cover by allowing water to permeate the soil. If an impervious material is used; special attention must be paid to drainage and the potential for erosion.
10. Minimize trail width and clearing in forest interiors to reduce the attractiveness of trails to edge-oriented species of wildlife that could displace more sensitive interior-forest species.
11. Design spur trails off of primary trails to provide access to ecologically sensitive areas, rather than routing a primary trail through or along a sensitive area.
12. Locate centers of activity, such as parking lots, picnic areas, and visitor centers, at the edge or outside of a greenway. Locate them in environments that are common in the area and durable.
13. Keep the number of travel routes within centers of activity to a minimum, clearly delineate them, and, if necessary, harden them. Barriers may be needed to confine and direct traffic. Subtle barriers, such as vegetation or grade variations, should be used as much as possible.
14. Use several management strategies and actions when attacking a specific problem. Most often a combination of approaches will increase the likelihood of success.
15. Consider all the likely consequences of any course of action. An action undertaken in one place to attack one problem may cause changes in other areas or create other problems.

Sources of Additional Information

This chapter has dealt with a wide variety of material in only a few pages. For more information on recreational impacts on the environment see *Wildland Recreation: Ecology and Management* by W. E. Hammitt and D. *N.* Cole (1987) and *Visitor lmpact Management: A review of Research* by F. R. Kuss et al. (1990). An excellent annotated bibliography on recreational impacts on wildlife, titled *Nonconsumptive Outdoor Recreation: An Annotated Bibliography of Human--Wildlife Interactions,* was prepared by Boyle and Sam--son (1983). Unfortunately, few books are available that offer much detail on management strategies and tools. However, a good source for trail design and management is *Trail Building and Maintenance* by Proudman and Rajala (1981).

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