INTERAGENCY
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# Impacts to Wildlife: Managing Visitors and Resources to Protect Wildlife

## CONTRIBUTING PAPER

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### Introduction.

Recreational visitation and associated economic contributions made to local and state economies provide a powerful catalyst for conserving public lands. Recreation enhances societal conservation and stewardship values. However, most protected natural areas, including parks, forests, rangelands, and wildlife refuges, are managed under a dual mandate to preserve predominantly natural settings and processes while also accommodating recreational visitation. Visitor activities can have deleterious impacts to protected area vegetation, soil, water, wildlife, and cultural resources (Hammitt et al. 2015; Marion et al. 2016).

The term impact denotes undesirable visitor-related effects to natural resources and/or wildlife. While managers seek to eliminate avoidable impacts, such as cutting trees for firewood or feeding wildlife, they must also minimize unavoidable impacts, such as trampling plants on trails and recreation sites (Marion 2016). Professional land and recreation managers and planners increasingly seek to identify unacceptable types and levels of visitor-related impacts by defining standards or "thresholds of change," which, when exceeded, prompt corrective management actions.

This paper reviews the management of recreation impacts to wildlife, including discussions of influential factors, impact indicators, and the range of management responses. This information is provided to assist recreation and land managers in avoiding or minimizing visitor impact to wildlife, particularly related to decisionmaking within the "Visitor Use Management Framework" (IVUMC 2016b). Such decisionmaking requires a thorough understanding of the different types of wildlife impact and the use-related, environmental, and managerial factors that influence them. Recreation access and management decisionmaking related to wildlife conservation require assessments of costs and benefits, generally on unit and regional scales.

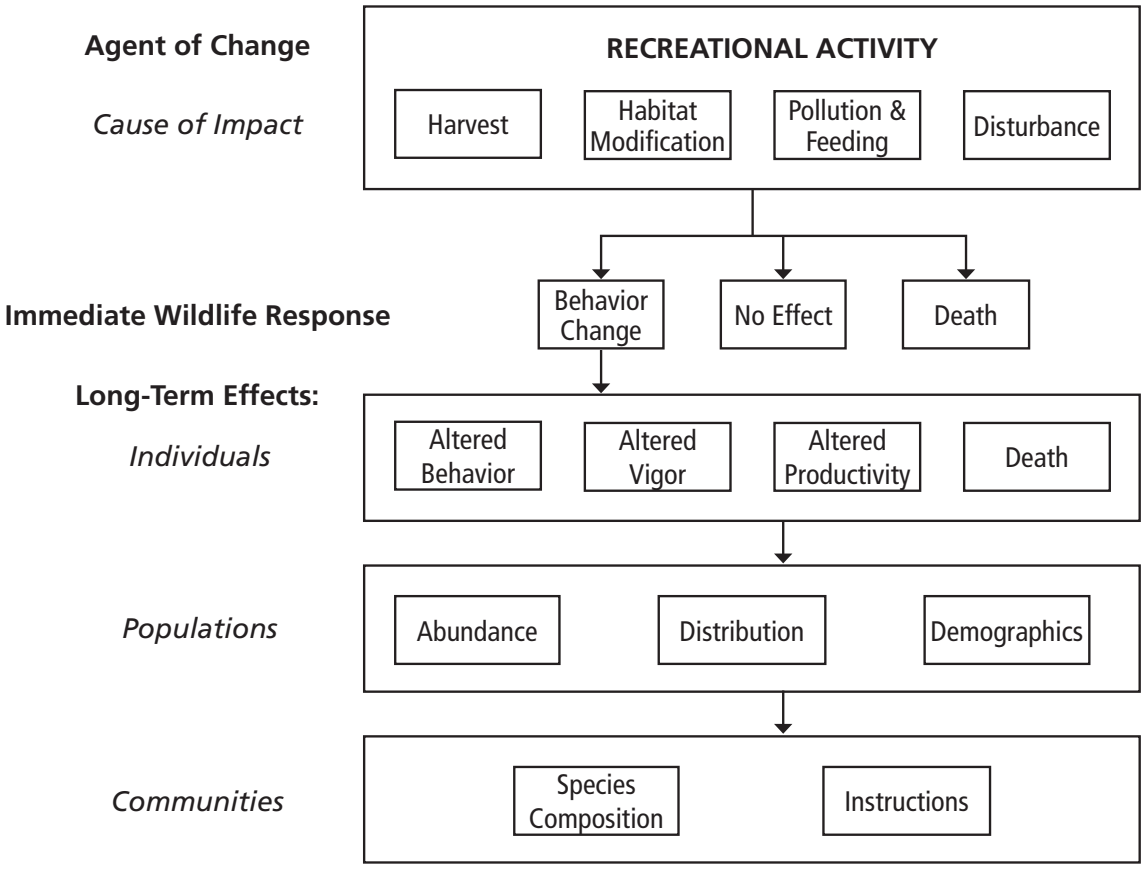
## Recreation Impacts to Wildlife.

Recreational activities in protected natural areas continue to increase and diversify, evolving from traditional activities, such as sightseeing, hiking, camping, and boating, to newer activities, such as mountain biking, ATV riding, bouldering, paddle boarding, and windsurfing. A recent outdoor recreation participation survey (Outdoor Foundation 2016) found that an estimated 142.4 million outdoor visitors participated in 11.7 billion outings in 2015. Wildlife-related activities rank among the most popular of outdoor pursuits, including fishing (55,746 thousand), hunting (15,526 thousand), and wildlife viewing away from home (20,718 thousand). Harvesting, seeing, hearing, and photographing wildlife can be an important or even essential component of a high-quality recreational experience for outdoor visitors. A core management challenge is achieving an optimal balance between visitors' desires to hunt, fish, and view wildlife and the needs of wildlife for habitats and natural processes that are largely undisturbed by protected area visitors.

Several potential impacts to wildlife have been described in the scientific literature (Knight and Gutzwiller 1995; Marion et al. 2016). These include direct effects, such as wildlife disturbance/harassment, habitat loss, and decrease in population (i.e., from hunting and fishing), and indirect effects, such as modification of wildlife behavior, temporal or spatial displacement from food and water, and shelter and habitat modification. Consumptive (harvest) recreational activities, such as hunting and fishing, can have long-term effects on wildlife populations (figure 1), directly altering the abundance, distribution, and demographics of wildlife. Hunting can also lead to changes in the relative abundance and composition of nongame fauna and flora (Knight and Cole 1991). The introduction and stocking of fish, particularly introduced species, can also alter aquatic food webs and have been cited as a contributing cause to the decline of native species (Liddle 1997). However, research is increasingly demonstrating significant impacts to wildlife from "nonconsumptive" recreational activities, such as hiking and wildlife viewing (Knight and Cole 1995; Steidl and Powell 2006). Further, while consumptive recreation activities have a long tradition of active management through regulations and permitting that limit the number of hunters and harvested fish and wildlife, nonconsumptive activities are generally unregulated and have greater numbers of participants with fewer regulations and limits on use.

Decisionmakers must understand how recreational activities impact wildlife, including the role of influential factors and how wildlife respond to visitor use, if they are to effectively manage visitation to avoid and minimize wildlife impacts. As illustrated in figure 1, impacts from recreational activity may include habitat modification caused by a variety of activities, such as introducing or dispersing nonnative plants or animals, removing woody vegetation for campfires, ecosystem-scale impacts from visitor-caused wildfires, and habitat fragmentation caused by formal and informal (visitor-created) trail networks and campsites (Hammitt et al. 2015; Marion et al. 2016; Wimpey and Marion 2011).

**Figure 1. A conceptual model of wildlife responses to recreational activity (Knight and Cole 1995).**




Pollution and feeding impacts come from boat motor oil and gas residues, soaps and lotions from washing and swimming activities, wildlife feeding and improper food and trash storage, and leaving trash and food behind. Soil eroded from trails and campsites can also pollute streams and lakes, contributing to turbidity and sedimentation impacts that reduce the quality of aquatic habitats for aquatic invertebrate and fish populations (Hammitt et al. 2015; Marion et al. 2016). Disturbance includes all visitor-wildlife interactions related to wildlife seeing, hearing, or smelling visitors and altering their behavior, habitat use, and level of stress (e.g., elevated heart rate) (Knight and Cole 1995; Liddle 1997). This category also includes removal of wildlife as pets, wildlife mortality from human pets, and vehicle collisions.

A small but growing collection of scientific literature on recreation impacts to wildlife exists within the domains of wildlife scientists, recreation ecologists, and human dimensions researchers. Some comprehensive but somewhat dated reviews are provided by Boyle and Samson (1985), Knight and Gutzwiller (1995), Leung and Marion (2000), and Newsome et al. (2005). More recent reviews are provided by Hammitt et al. (2015), Larson et al. (2016), Marion et al. (2016), and Newsome et al. (2013). A comprehensive review of trail and road-related impacts to wildlife is provided by Snetsinger and White (2009). These studies highlight six recreational factors that influence wildlife responses.

1. **Type of recreational activity.** Activities vary by their potential to disturb wildlife. Activities that involve high speeds and loud sounds have a greater potential to disturb wildlife because of the substantially greater areas affected (Knight and Cole 1995). For example, motorized activities, mountain biking, and trail running have been cited as having a greater potential to startle and scare wildlife than slower trail activities, such as hiking and nature observation (Knight and Gutzwiller 1995). However, some recent studies have found less impact from motorized uses, suggesting that wildlife are more threatened by the human form, which can be masked when visitors travel in or on vehicles, or suggesting that nonmotorized visitors are able to more closely approach and surprise wildlife before being detected (Larson et al. 2016).

*Camper packing food into a secure canister.*

2. **Recreationist behavior.** Visitors who directly approach wildlife are perceived as threatening. Wildlife are less disturbed by travel that is slow, quiet, and in directions parallel to or away from them.

3. **Impact predictability.** Wildlife are able to adapt to and tolerate consistent nonthreatening recreational activities occurring on roads, trails, and recreation sites. Unpredictable recreational activity in less visited off-trail locations can cause greater impact.

4. **Impact frequency and magnitude.** Repeated human interaction and disturbance of wildlife can exceed a threshold of tolerance that causes wildlife to leave a preferred habitat. Particularly threatening incidents can also disproportionately affect wildlife.

5. **Impact timing and location.** Wildlife have seasonal and locational sensitivities to recreational disturbance, such as when nesting, giving birth, and raising young, or in the winter when food is scarce and energy expenditures are high.

Wildlife express learned behaviors based on their personal experiences and interactions with humans. Three common behavioral responses are avoidance, habituation, and attraction (Knight and Temple 1995). Avoidance behavior is the most common innate response of wildlife to contact with outdoor visitors, magnified by visitor behaviors perceived as threatening. When visitors approach too closely, wildlife run or fly away. A common indicator of their tolerance for humans is expressed as their flushing or "flight distance"—the approach distance that caused them to flee the area (Stankowich 2008; Taylor and Knight 2003). When wildlife flee, they are generally leaving an area of preferred habitat for an area with less desirable food, water, or cover. Fortunately, most wildlife have a capacity to habituate to (tolerate) consistent nonthreatening recreational activity, though they may still be experiencing some degree of stress. Habituation is generally an optimal behavioral response, allowing wildlife and visitors to coexist (Knight 2009). Attraction behavior develops when wildlife develop a positive association with visitors, generally because of the provision of food (food conditioning), water, or protection from predators (Knight 2009; Orams 2002). Wildlife obtain food from visitors through purposeful feeding; by dropped, spilled, or discarded food; or when visitors fail to adequately store their food and trash.

### Wildlife Impacts Along Trails.

Recreationists generally spend the majority of their time in protected natural areas on recreational trails and campsites, so examination of the literature related to these infrastructure components is an important focus. Visitors hiking on trails may disturb wildlife, displacing them from trail corridors during times of heavy use (temporal displacement) or permanently (spatial displacement). In an experimental study, Riffell and others (1996) evaluated the effects of repeated intrusion by hikers to avian communities in Wyoming's Medicine Bow National Forest for 10 weeks during the breeding season over 5 years. Their study found no cumulative or yearly declines in seasonal species richness, mean richness, or mean total abundance. They did find that repeated intrusions altered the composition of the community represented by the most common species, but no widespread impacts on avian community structure were documented. In contrast, Miller and others (1998) found the composition and abundance of birds to be altered in a Colorado grassland and forest setting, with an area of influence of approximately 75 m (zone where human activity may displace wildlife from suitable habitat). Generalist bird species were more abundant near trails, and birds were less likely to nest near trails in grasslands, where nest predation was more common.

Shifting to mammals, Miller and others (2001) evaluated the effects of hikers with dogs on deer, finding that the alert and flush distances, distance moved, and area of influence (table 1) were all greater when activities occurred in off-trail versus on-trail settings. Off-leash dogs elicited shorter flush distances than on-leash dogs and hikers without dogs. The presence of a dog also resulted in a greater area of influence, alert and flush distance, and distance that deer moved compared to hikers without dogs.

**Table 1. Common indicators of recreational disturbance to wildlife.**

| ALERT DISTANCE | FLUSH OR FLIGHT INITIATION DISTANCE | DISTANCE MOVED | AREA OF INFLUENCE |
|---|---|---|---|
| Distance at which an animal detects and pays attention to an approaching human. | Distance at which an animal flees an approaching human. | Distance that wildlife move when flushed. | A measure of habitat area from which wildlife are displaced because of recreational disturbance. |

A comparative experimental study of hiker and mountain biker impacts to mule deer, bison, and antelope in Utah was conducted by Taylor and Knight (2003). For each species, animals did not respond differently to hiking vs. mountain biking, but all three exhibited a 70% probability of flushing from on-trail visitors within 100 m of trails. These species reacted more strongly to off-trail visitors. Researchers noted that bikers could disturb a greater number of animals for a given amount of time because of their greater speed along trails. In contrast, Papouchis and others (2001) did find significant differences from a study of bighorn sheep interactions with hikers, mountain bikers, and vehicles in Canyonlands National Park. Sheep fled from mountain bikers only 6% of the time, rising to 17% for vehicles, and 61% for hikers. The latter was attributed to hikers more frequently traveling off-trail and directly approaching the sheep. Additional explanations are that wildlife respond more to the human form, particularly because of an association with hunters, while both bikes and vehicles mask the human form. Hikers are also slower and more quiet, able to approach closer to wildlife before being spotted, eliciting a more substantial response.

These are just a few of many studies that can be found in the scientific literature. Findings are often inconsistent due to the unique life histories of each animal and the complex array of factors influencing their behavioral responses. Different species can have different responses to interactions with visitors, and indicators such as flight distances for the same species can be quite variable in both time and space. For example, a study of bald eagles in a Minnesota national forest documented flushing distances from hikers ranging from 57 to 991 m, yet unsuccessful nests had no greater frequency of known human activity within 500 m than successful nests (Fraser et al. 1985). In popular known locations where visitors commonly gather in large numbers to photograph and view wildlife, such as along park roads or in roadside meadows, land managers may require additional actions and monitoring to keep visitors and wildlife safely separated.

### Wildlife Impacts at Recreation Sites.

Outdoor visitors spend considerable time on day-use and overnight recreation sites, where their activities can displace wildlife or alter wildlife habitats by reducing woody and herbaceous vegetation cover, felling and burning dead snags important to cavity nesting wildlife, eroding soils into waterways, or attracting wildlife to unnatural food sources. Displacement impacts can be more substantial in arid environments where recreation sites are located near vital water sources and riparian habitats (Knight and Gutzwiller 1995).

Wildlife feeding can also be common at recreation sites, promoting harmful food attraction behaviors and food dependencies. Actions that cause such food conditioning may be intentional but are often unintentional, resulting from spilled, dropped, and discarded food or from poorly stored food and trash. Some tourism operators routinely feed wildlife (termed food provisioning) to promote improved wildlife observation opportunities for their clients (Knight 2009; Orams 2002). This can alter natural population levels, create dependencies on unhealthy human food, and lead to aggressive and potentially dangerous human interactions. For example, food-attracted bears pose a clear threat to visitor safety and are commonly relocated and killed by public land managers (Stringham 2013). Coleman and others (2013) attributed food attraction behavior to their finding that grizzly bears in Yellowstone National Park were significantly more likely to roam in close proximity to occupied campsites than to random locations.

### Relationship to Amount of Use.

For visitor use management and carrying capacity decisionmaking, a key influential factor is understanding how recreational access and the level of visitor use may affect wildlife conservation objectives. This section reviews that literature, but unfortunately, as noted by Hammitt and others (2015): "The relationship between amount of recreational use and wildlife impacts is not well understood. Very few studies have systematically examined the effects of varying numbers of visitors on wildlife." Such studies are methodologically challenging because they need to measure and account for both environmental and population dynamic influences before and during the experimental addition of recreation use as a "cause-and-effect" influence. Further, these authors state that there may be no uniform use-impact relationship for wildlife: "the number of visitors cannot be considered in isolation from species requirements and habitats, population dynamics, setting attributes, and type of recreational use" (Hammitt et al. 2015). Type of recreational use can include the type of recreational activity and mode of travel; frequency and regularity of use; number of people at one time; visitor behaviors; and the type, degree, and intensity of wildlife interaction and disturbance.

*Visitors taking photographs of wildlife (mountain goats).*

Knight and Cole (1995) attribute the learned component of wildlife responses to humans to the number and outcome of prior interactions between individual wildlife and humans. A number of studies reveal that wildlife readily learn and adapt to visitor intrusions to their habitats. In a Minnesota bald eagle study, the approach distance at which eagles flushed increased as repeated observers approached their nests (Fraser et al. 1985). Nesting adults of red-winged blackbirds, robins, and goldfinches that were repeatedly visited by researchers became more aggressive over time (Knight and Temple 1986). However, as previously noted, a comprehensive longitudinal study on the effects of repeated intrusions by hikers to avian community richness and abundance found no cumulative declines over 5 years (Riffell et al. 1996). The authors suggest that individuals displaced one year may have been replaced by others in subsequent years, or individuals may have become habituated to the intrusions. In another study, Lusseau and Bejder (2007) examined the impact from tourism boats on bottlenose dolphins, concluding that animals subjected to repeated intrusions may cope by adopting short-term avoidance tactics or long-term habitat abandonment; animals unable to elude the disturbance may suffer reduced fitness and reproductive success.

In one of the few studies that assessed level of use effects on wildlife disturbance, Mallord and others (2007) examined woodlark density on 16 English heathland sites having varying levels of use. Based on regression modeling, woodlark density was lower on sites having higher levels of disturbance. Specifically, when a threshold of eight disturbance events per hour was reached, the probability of suitable habitat being colonized was reduced to below 50%. However, their model predicts that the impact on woodlark population size depends on visitor numbers and spatial distribution; a doubling of visitor numbers has little effect, while the same number distributed evenly across the area would have significant negative impacts on the population. However, visitor-distribution patterns in protected areas are quite unbalanced; recreationists generally congregate on the more popular, well-established trails and recreation sites with little to no visitation to the vast majority of backcountry areas (Hammitt et al. 2015). Mallord and others (2007) also caution that managers should be aware that behavioral studies, such as those that examine flushing distance, can be misleading, as the most vulnerable species may have adequate adjacent alternative habitats. Even studies reporting reductions in breeding success attributable to visitor disturbance must also assess the population consequences of the reduction.

Liley and Sutherland (2007) also emphasize that behavioral impacts and even demonstrated effects on breeding success or survival cannot generally be extended to predict wildlife population size effects. They developed a population model allowing predictions of the effect that changes in visitor numbers along a coastline have on the size of a ringed plover population. The model can be useful to decisionmakers. For example, by showing that increased use in high-use areas has no effect on plover populations, while predicting the population consequences of similar increases in areas having low to moderate levels of use. The model also demonstrates differential effects of increasing use in high-quality versus low-quality habitats.

In a study of mammals, bighorn sheep increased their avoidance responses to hikers as the number of negative encounters increased (King and Workman 1986). In a more recent study, Papouchis and others (2001) found substantial variation in responses of bighorn sheep to varying levels of visitor use; some animals habituated to the high-use areas while other animals consistently avoided these areas. The habituated animals had fewer responses to vehicles and mountain bikers compared to the habitats having lower visitor use. For the local population, there was an avoidance of the road and high visitor use area, representing 15% less use of suitable habitat compared to the low-use area. Sensitivity to hikers increased for males during the autumn rut period and for females during spring lambing.

*Visitors view elk enjoying green space.*

Van der Zande et al. (1984) examined the relationship between level of visitor use and bird densities in the Netherlands and reported that the same absolute increase in traffic intensity had a larger disturbance effect in low-use areas than in higher use areas. An implication is that it is better to allow use to increase in areas that are already popular than to disperse or spread use over a larger area. In high-use shoreline areas, van der Zande and Vos (1984) found that numbers for 11 of 12 bird species were lower than in areas having fewer visitors. Lower wildlife numbers were associated with recreation levels of 8-37 visitors per hectare. Van der Zande et al. (1984) calculated recreation intensity for various woodland areas to correlate with avian densities, finding significant negative correlations with the densities of 8 of 13 bird species. Differential susceptibility was found for the same species between deciduous and coniferous woodlands. They also calculated the recreation intensity necessary to reduce wildlife density by 50% for the most susceptible species, suggesting that such calculations and maps could be useful for planning and management decisionmaking.

A more recent process that could aid visitor use management planning is proposed by Eaton and others (2014), who demonstrate application of thresholds to management problems through a formalized decision-analytic process. Applied as a case study of recreation impacts on nesting golden eagles in Denali National Park, the authors describe how managers can define and manage acceptable levels of nesting site occupancy. They apply structured decision making (SDM) to deconstruct the decisions into components, identifying sources of uncertainty and impediments, and finding the optimal solution by integrating the components. This process is easily incorporated into adaptive management decisionmaking.

## Managing Recreation Impacts to Wildlife.

This section reviews the current state-of-knowledge on alternative recreation management practices that can avoid or minimize visitor impacts to wildlife and their habitats. As reviewed by Marion (2016), visitor use management is a new proactive and adaptive process for managing characteristics of visitor use and the natural and managerial setting using a variety of strategies and tools to achieve and maintain desired resource conditions and visitor experiences. The Interagency Visitor Use Management Council emphasizes that managing visitor access and use for recreational benefits and resource protection is inherently complex, requiring consideration of natural and social science studies, management experience, and professional judgment (IVUMC 2016b). Research and monitoring strategies are needed to provide managers with objective information on the impacts of visitation so they can evaluate their significance, acceptability, and the need for management interventions. Research and monitoring can also provide information on the relative influence of factors that can be manipulated to avoid or minimize visitation impacts. More comprehensive information about these interrelationships can improve the sustainability of visitor use management practices.

A comprehensive array of management interventions has been developed to resolve visitor impact management problems (Hammitt et al. 2015). Cole and others (1987) proposed eight categories of management strategies and tactics with management guidance that seek to manipulate three types of factors: use-related (e.g., amount or type of use and user behaviors), environmental (e.g., environmental resistance and resilience related to vegetation or soil attributes, topography, and others), and managerial (infrastructure and site management) (table 2). The following material summarizes the strategies and tactics most relevant to human-wildlife interactions.

### STRATEGIES 1 AND 2: REDUCE USE.

Existing research is inconclusive regarding use limitation as an effective wildlife protection strategy. Limiting use in higher use areas appears ineffective while limiting use in lower use areas may be effective when demonstrated by research or modeling. Use limitation in low-use areas may also be more vital when the affected area represents particularly high-quality or sensitive wildlife habitat, particularly for rare or threatened species. Use may also be limited through a physical capacity imposed by a facility, such as a viewing platform or blind overlooking a rookery. Indirect methods for reducing use in an area of concern include eliminating or

reducing the capacity of facilities such as parking lots, expanding or improving facilities in alternative areas, discouraging or encouraging use in certain areas, and charging higher fees or requiring a paid guide to visit a more sensitive area (Hammitt et al. 2015).

### STRATEGIES 3 AND 4: MODIFY THE LOCATION AND TIMING OF USE.

Visitor use can be shifted from areas of high-quality wildlife habitat to areas of low-quality habitat by moving trails, recreation sites, and facilities. For example, camping can be moved away from riparian areas or limited water sources in arid environments, or it can be concentrated onto a limited number of sustainably designed designated sites. Off-trail travel can be discouraged or even prohibited in selected sensitive areas. Visitor use can be discouraged or prohibited during certain times within sensitive wildlife habitats. For example, when a section of cliff is closed to protect a peregrine falcon nest.

### STRATEGIES 5 AND 6: MODIFY THE TYPE OF USE, VISITOR BEHAVIOR, AND VISITOR EXPECTATIONS.

Since its creation in 1994, the U.S. Leave No Trace program has grown into a successful international educational program with a mission to develop and promote low impact outdoor skills and ethics. Guided by a nonprofit, the Leave No Trace program has been adopted by the federal land management agencies, many state and local public land management agencies, numerous outdoor adventure and camp programs, and the Boy and Girl Scouts of America. Pertinent wildlife-related information follows, but more comprehensive information can be found at its website (www.LNT.org) and in its printed materials and book (Marion 2014). Other educational programs include Keep Wildlife Wild, Watching Wildlife (https://www.nps.gov/subjects/watchingwildlife/index.htm), and Tread Lightly (www.treadlightly.org).

**Dispose of Waste Properly.** This Leave No Trace principle encourages visitors to pack out all trash, waste, food, and litter by: (1) burying solid human waste at least 200 ft from water, camp, and trails; (2) cleaning up all trash and dropped or spilled food and packing it out; (3) straining dishwater of food particles and packing them out; (4) using small amounts of biodegradable soap and broadcasting wash water more than 100 ft from water sources; and (5) packing out or burying fish entrails. In front country settings, such as picnic areas and car campgrounds, visitors need to check with local managers to find out if food and trash can be stored in their vehicles or if it must be placed in wildlife-proof food storage containers and trash receptacles.

**Leave What You Find.** This Leave No Trace principle encourages visitors to take photos but leave plants and wildlife "as found" for others to enjoy. For example, box turtles can live over 100 years in the wild but often survive only a year or two in captivity (Marion 2014). Fishers, hunters, and those who pick berries, nuts, or mushrooms are urged to learn and follow regulations, permitting, and low-impact practices. Visitors are also encouraged to learn about nonnative plant and animal species and practices that prevent their transport, introduction, and dispersal to protected areas.

**Respect Wildlife.** In addition to storing all food, trash, and smellables throughout the trip and never feeding wildlife, this Leave No Trace principle encourages visitors to respect wildlife, as the recreationists are visitors to the wildlife's home. This includes observing wildlife from a distance by using binoculars and telephoto lenses, halting an approach to wildlife if they react to your presence, practicing quiet nonthreatening behaviors, and avoiding sensitive areas and times, such as when wildlife are nesting, giving birth, raising young, or coping with wintertime snow and cold weather. This principle also emphasizes leaving pets at home or restraining them at all times with a leash.

*Visitor photographs wildlife (wolf).*

## STRATEGIES 7 AND 8: MODIFY RESOURCE RESISTANCE AND MAINTAIN OR REHABILITATE THE RESOURCE.

Many existing protected area trails and recreation sites were originally visitor-selected or created and may be poorly located or have unsustainable designs. Improved designs, site hardening practices, and maintenance can increase their ability to sustain use while substantially reducing resource impact. Trail networks can be concentrated in areas of lower quality wildlife habitat, with low trail densities or no trails in more sensitive or important habitats. Strategies such as using wildlife-proof food storage containers, cable systems that lift food or trash out of reach of animals, and wildlife-proof trash receptacles can substantially reduce food attraction (conditioning) problems. Constructed boardwalks with railings and viewing platforms or blinds can often allow expanded wildlife viewing opportunities with the same or less impact to wildlife. Fencing can also be constructed to protect rookeries or nesting areas. Degraded facilities can be closed and natural conditions restored.

**Table 2. Strategies and tactics for managing recreation impacts to resources or visitor experiences.**

| I. REDUCE USE OF THE ENTIRE AREA | |
|---|---|
| • Limit number of visitors in the entire area<br>• Limit length of stay in the entire area<br>• Encourage use of other areas | • Require certain skills and/or equipment<br>• Make access more difficult throughout the entire area |

## II. REDUCE USE OF PROBLEM AREAS

- Inform potential visitors of the disadvantages of problem areas and/or advantages of alternative areas
- Discourage or prohibit use of problem areas
- Limit number of visitors in problem areas
- Encourage or require a length-of-stay limit in problem areas
- Make access to problem areas more difficult and/or improve access to alternative areas
- Eliminate facilities or attractions in problem areas and/or improve facilities or attractions in alternative areas
- Establish differential skill and/or equipment requirements
- Charge differential visitor fees

## III. MODIFY THE LOCATION OF USE WITHIN PROBLEM AREAS

- Discourage or prohibit camping and/or stock use on certain campsites and/or locations
- Encourage or permit camping and/or stock use only on certain campsites and/or locations
- Locate facilities on durable sites
- Concentrate use on sites through facility design and/or information
- Discourage or prohibit off-trail travel
- Segregate different types of visitors

## IV. MODIFY THE TIMING OF USE

- Encourage use outside of peak use periods
- Discourage or prohibit use when impact potential is high
- Charge fees during periods of high use and/or high-impact potential

## V. MODIFY TYPE OF USE AND VISITOR BEHAVIOR

- Discourage or prohibit particularly damaging practices and/or equipment
- Encourage or require certain behavior, skills, and/or equipment
- Teach a wilderness ethic
- Encourage or require a party size and/or stock limit
- Discourage or prohibit stock
- Discourage or prohibit pets
- Discourage or prohibit overnight use

## VI. MODIFY VISITOR EXPECTATIONS

- Inform visitors about appropriate uses
- Inform visitors about conditions they may encounter

## VII. INCREASE THE RESISTANCE OF THE RESOURCE

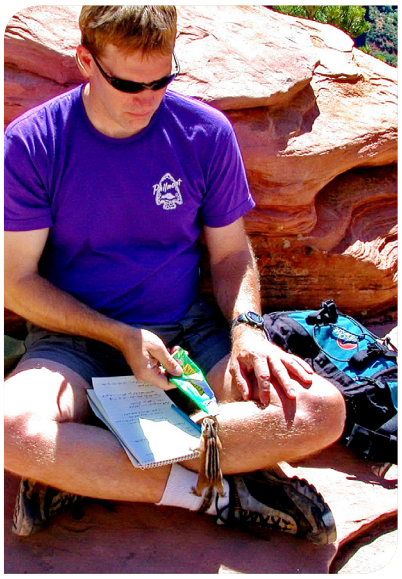
- Shield the site from impact
- Strengthen the site

## VIII. MAINTAIN OR REHABILITATE THE RESOURCE

- Remove problems
- Maintain or rehabilitate impacted locations

Source: Cole and others (1987)

## Summary and Conclusions



*Researcher studies food attraction behavior.*

Human-wildlife interactions will inevitably increase in the future as undeveloped landscapes continue to shrink and human populations and visitation to protected areas expand. In response, recreation ecology, a field of study that investigates the types and severity of recreation-related resource impacts and how they are influenced by use-related, environmental, and managerial factors, could be expanded to involve more scientists and land managers with wildlife ecology and wildlife management expertise. In the photo to the left, the author at Zion National Park in Utah developing measures of the strength of food attraction behavior for a study designed to deter visitors from feeding wildlife (Marion et al. 2008). Further develops and integration of scientific and technical knowledge in visitor use management and wildlife management can help sustain high-quality recreational experiences while conserving native populations of wildlife and their habitats.

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