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Science & Policy Brief

Addressing the Ecological Effects of Off-Road Vehicles (ORVs)

Key Points

- Management of cross-country travel by motorized off-road vehicles (ORVs) is one of the most serious issues facing public land management agencies.
- Like other outdoor recreational pursuits, ORV use has risen dramatically in recent decades, increasing the conflicts between recreational demand and environmental protection.
- The effects of ORVs on wildlife range from direct mortality to increased physiological stress to displacement from favored habitat and other fragmentation effects.
- ORVs damage native vegetation and are a key cause of the spread of invasive plants in many areas.
- Soils, especially in arid regions, are often severely damaged by ORVs. Increased erosion, water pollution, and air pollution are other negative environmental effects caused by ORVs.
- As demand for off-road recreational opportunities increases, land management agencies must develop science-based plans to manage the ecological threats caused by ORV use and ensure adequate monitoring and enforcement of regulations.
- Ecological effects must be the first and foremost consideration in making management decisions. Desires for recreational access cannot take priority over protection and conservation of natural resources on public lands.

Background

Off-road vehicles (ORVs), including all-terrain vehicles (ATVs—small, open motor vehicles having one seat and three or more wheels fitted with large tires) and dirt bikes (off-highway motorcycles),

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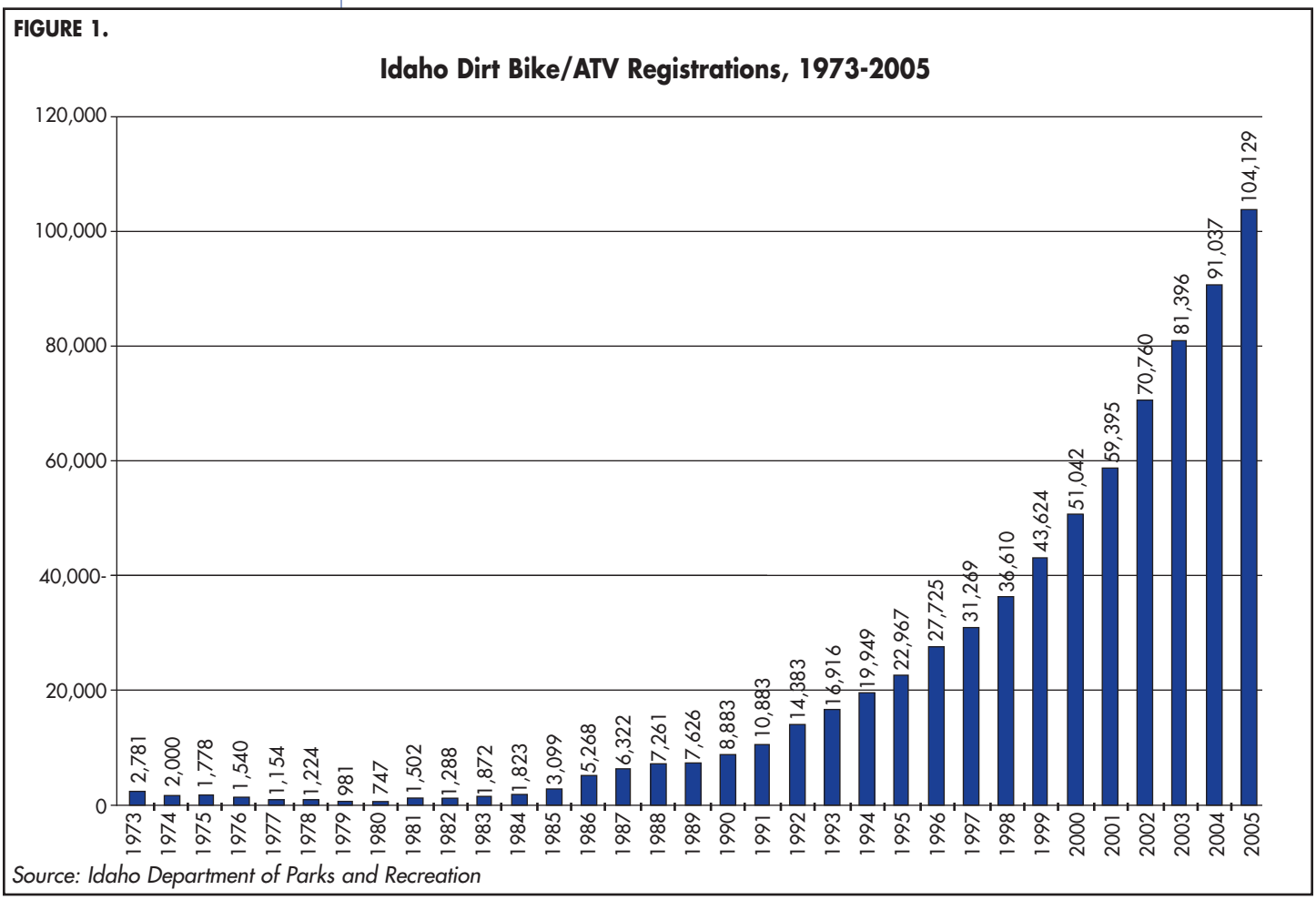
Mandating that ORVs stay on designated trails is a good first step toward reducing the ecological impacts of ORVs while continuing to provide recreational opportunities.

present one of the most serious management issues facing public lands agencies. Widespread concern about ecological damage from cross-country travel by motorized vehicles was recently reflected by U.S. Forest Service Chief Dale Bosworth, who identified unmanaged recreation, including ORV use, as one of the top four threats to the health of national forests across the country. Such concerns spurred the Forest Service to implement a new travel management rule in November 2005, providing a consistent national framework for local decisions on where and how ORV use is permitted through designation of a motorized road and trail system and prohibition of cross-country use (U.S. Forest Service 2005). To ensure compliance on the part of visitors, the rule also requires a motor vehicle use map to be made available to the public at no cost. This rule can be considered a first step toward reducing the ecological impacts of ORVs while continuing to provide recreation opportunities. The next step is for the Forest Service and other agencies to ensure that ecological analyses, monitoring, and enforcement plans are implemented in order to identify and respond to the effects of past and future ORV use.

ORV use has risen dramatically in recent decades. In 1960, so few people used ORVs that they were not even addressed in a nationwide survey on outdoor recreation. The number of ORV users in the United States rose from 5.3 million in 1979 to 28 million by the late 1990s (Bowker et al. 1999); the number of ORVs on public lands also increased substantially during this time period (Schubert & Associates 1999). In the state of Idaho alone, ORV registrations rose from just under 2,800 in 1973 to

FIGURE 1.



Source: Idaho Department of Parks and Recreation

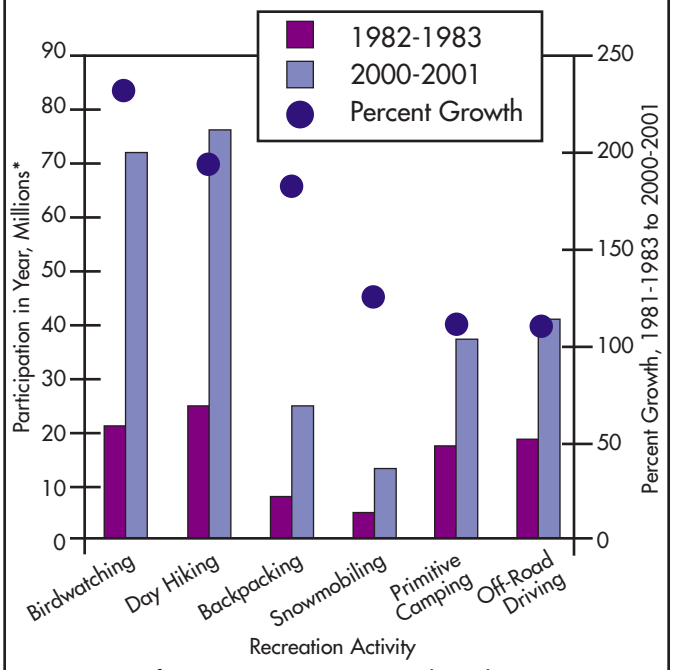
over 100,000 in 2005 (Figure 1). A Forest Service survey reported 42 million ORV users on national forest lands nationwide from fall 2003 through spring 2004 (however, this number includes all types of vehicles—e.g., jeeps, 4x4 trucks, etc.—that were driven off a paved or gravel road)(Cordell et al. 2004). Moreover, as ORVs have gained in popularity they have also gained in horsepower and agility, with today's vehicles able to tackle even the most challenging backcountry terrain.

These trends are best understood in the context of increasing interest in outdoor recreational pursuits in general. In 2000-2001, 97% of Americans aged 16 and over reported participating in some outdoor activity (Cordell et al. 2004). In surveys of trends in outdoor recreation (Figure 2), participation in off-road driving (in all types of vehicles, including jeeps, 4x4 trucks, etc.) increased 110% between 1982-1983 and 2000-2001 (Cordell et al. 2004). However, off-road driving was not among the five fastest-growing activities over that period, and the number of participants in the fastest-growing activity, birdwatching, grew by 231%. The activities in greatest demand by Americans were walking, family gatherings, sightseeing, picnicking, and visiting educational sites. The surveys also demonstrated that Americans placed a higher importance on protecting and conserving water sources, designating wilderness, and designating non-motorized trail systems than on designating motorized trail systems. Although this brief focuses on addressing the ecological impacts of ORV use, it is important to recognize that all types of outdoor recreation can have negative impacts on public lands.

While the ecological effects of ORVs have been studied for the past 25 years throughout the United States, the resulting knowledge has been slow to influence land management policy. Meanwhile, the impacts of ORVs on ecosystems have increased across the United States and throughout the world. The Wilderness Society undertook an extensive review of the relevant scientific literature, and found it demonstrates that ORVs cause significant and severe direct, indirect, and cumulative impacts on the environment, including wildlife mortality, habitat loss, erosion, soil compaction, destruction of stream bank stability, impairment of water quality, and other effects. The time period required for landscapes to recover from the impacts of ORVs remains unknown. Because of the significance of the impacts, it is important to assess and interpret the available information on the effects of ORVs in order to develop recommendations for better management of ORV use on public lands, and to encourage further research that will address unknown long-term effects on ecological processes and help refine management decisions.

FIGURE 2.

Trends in Participation in the Fastest-Growing Outdoor Recreation Activities, USA



* Estimates of participants per year are based on surveys sampling the U.S. population, distributed across different geographic regions and social groups, and weighted according to U.S. census data.

Source: Cordell et al. 2004

Ecological Impacts

Effects on Wildlife

ORVs have a wide range of adverse effects on many species of wildlife (Joslin and Youmans 1999, Defenders of Wildlife 2002). The best-known example is the desert tortoise (*Gopherus agassizii*) in the Mojave Desert (Bury and Luckenbach 2002),

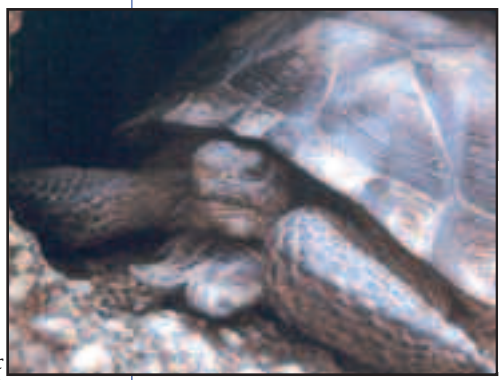


PHOTO COURTESY NPS.GOV

The desert tortoise (*Gopherus agassizii*) is sometimes crushed to death under the wheels of larger ORVs—one of a wide range of adverse effects that ORVs have on wildlife.

PHOTO BY MICHAEL QUINTON/MINDEN PICTURES

Habitat fragmentation from ORV trails limits the movements of many wildlife species. For example, bobcats (*Lynx rufus*) rarely cross roads and trails, which become de facto home-range boundaries.

which is sometimes literally crushed to death under the wheels of larger ORVs. The vehicles also destroy underground burrows that provide refuge for tortoise and their young during the daylight hours. The nests, eggs, and young of shorebirds, too, may be destroyed by ORVs (Brown and MacLachlan 2002). Finally, direct mortality from ORVs in beach habitat of the Black Bay National Wildlife Refuge in Virginia has been linked to the decimation of the ghost crab (*Ocypode quadrata*) population region-wide (Fialka 1975).

ORV trails that open up access to remote areas may increase the likelihood of poaching. Reports of hunters on ATVs taking illegal "flock shots" at running pronghorn antelope (*Antilocapra americana*) from long ranges are on the rise. ORV access to remote areas increases the vulnerability to trapping of pine marten (*Martes americana*), fisher (*Martes pennanti*), and wolverine (*Gulo gulo*)(Weaver 1993). In one study in the central Rocky Mountains, 21 of 25 human-caused wolf (*Canis lupus*) mortalities occurred within 200 meters of a motorized trail (Boyd and Pletscher 1999).

In addition to direct mortality from ORVs, numerous species of wildlife including birds, reptiles, and large and small mammals are disturbed by ORV traffic and show a variety of physiological effects including accelerated heart rate and metabolic function, increased stress, and reproductive failure (Havlick 2002). Many small mammals and reptiles use their acute sense of hearing and ability to detect vibrations to elude predators and capture prey, and noise from ORVs interferes with these senses. In kangaroo rats (*Dipodomys spectabilis*), ORV noise can cause frantic behavior, ear bleeding, and temporary loss of hearing (Berry 1980, Bury 1980).

Habitat fragmentation. Habitat fragmentation, which occurs when habitat loss or human-made barriers divide an area of relatively continuous habitat into smaller, disconnected parcels, frequently alters the behavior of wildlife species. Ecologists L. Harris and G. Silva-Lopez (1992) have written that "Roads are perhaps North America's number one fragmenting force." Roads and trails can act as barriers to animal movements and cause avoidance and displacement effects not just because of the bare surface of the road or trail, but also because of edge effects, including altered roadside habitat (vegetation changes may extend several tens of meters from the edge of the road) and the noises, emissions, movements, and lights associated with traffic (Bennett 1991, Larkin 1996, Noss 1996, Trombulak and Frissell 2000, Gaines et al. 2003). User-created ORV trails have the same fragmentation effects as roads do, but their greater density can cause worse cumulative impacts (Gaines et al. 2003, Gilbert 2003).

Wildlife species that must move and/or migrate between breeding, foraging, and/or overwintering habitats—ranging from amphibians at small scales to large ungulates at vast ones—may be particularly

vulnerable to habitat fragmentation produced by dense road or trail networks. For various physical and psychological reasons, some species will not cross roads or trails (Noss 1996, Gilbert 1998). For example, female bobcats (*Lynx rufus*) rarely cross roads, which become de facto boundaries circumscribing their territories (Foster and Humphrey, unpublished data reported in Hannah 1992).

Other species avoid using habitats near roads or heavily used trails. Numerous studies report that grizzly bears (*Ursus arctos*) avoid habitat near ORV trails (for example, within 500 meters in one study in Montana) (Mace et al. 1996, Graves 2002). In areas of heavy ORV use within the Big Cypress National Preserve, the Florida panther (*Puma concolor coryi*) avoids preferred hunting areas and home ranges (Janis and Clark 2002). ORVs have greater negative impacts on elk (*Cervus elaphus*) than do hikers, horseback riders, or bicyclists: in one study, elk began moving when ATVs were as far away as 2,000 yards but tolerated hikers to within 500, horseback riders within 800, and bicyclists within 1,300 yards (Wisdom et al. 2004). In addition, elk run from ATVs but tend to walk away from hikers unless startled at close range. Elk have also been shown to abandon large areas of high-quality forage when exposed to ORV traffic, shifting to small, overgrazed forest patches where ORV trails are absent (Morgantini and Hudson 1979). These types of effects can be particularly significant where ORVs are allowed in Inventoried Roadless Areas, which act as important refuges for wildlife (Gilbert 2003).

Effects on Vegetation

ORVs reduce perennial and annual plant cover, density, and overall aboveground biomass (Hall 1980). The degree of loss depends on the intensity of ORV use, but even a single vehicle pass can destroy or disrupt many types of plants and shrubs. Plants with shallow root systems typical of arid regions are especially vulnerable (Wilshire 1983, Lacey et al. 1997). Smaller shrubs are often the first to be damaged or eliminated. Damage to vegetation also increases as the summer progresses due to the phenology of many plants found along trails (Payne et al. 1983). In the spring, grasses and forbs are growing and more pliable, but as the plants mature they become dry and brittle, and thus more susceptible to ORV damage. In the Intermountain West, where droughts are frequent and the summers are hot and dry, the chance of vegetation damage is great and plants are less likely to reestablish at this time of year. Unfortunately, this stress period for plants coincides with the peak use of ORVs, thus magnifying the problem. Restoration of disturbed areas occurs only through the process of natural revegetation, and recovery may take many years (Rowlands 1983). This is especially true in arid regions.

In addition to destroying native vegetation, ORVs are frequently cited as the key link in the spread of invasive or noxious plants, which are becoming a threat to

PHOTO COURTESY US FOREST SERVICE

Off-trail riding on ORVs destroys vegetation, damages soils, and creates severe erosion problems, especially in arid areas. The time period required for ecosystems to recover from many ORV impacts remains unknown.

numerous grassland and forest ecosystems in the United States. Roads and trails serve as corridors for non-native plant invasions, and ORVs commonly transport a variety of non-native seeds. In Montana, seeds of an invasive plant, spotted knapweed (*Centaurea maculosa*), were shown to hitchhike by the thousands on the undercarriage of ORVs for distances up to 10 miles (Lacey et al. 1997). In Wisconsin, it has been estimated that ORVs could spread 200 million seeds statewide over the next 20 years (Rooney in submission). Where riding off-trail is allowed, ORVs remove competing vegetation and disturb soil, creating a seedbed for non-native seeds. Some noxious weed seeds are more likely to germinate and crowd out native plants in areas where soil has been compacted by ORVs.

Land management agencies need to ensure that ecological analyses, monitoring, and enforcement plans are implemented in order to identify and respond to the effects of past and future ORV use.

Effects on Soils

Soils, especially in arid regions, can be severely damaged by ORVs. The loss of vegetative cover increases susceptibility to wind and water erosion, which accelerates decomposition of remaining organic matter, weakens soil aggregate stability, and results in the formation of inorganic surface crusts. These surface crusts increase runoff, inhibit germination and emergence of seedlings, and reduce water penetration, resulting in a harsher environment where it is more difficult for plants to survive (Dregne 1983). Other natural soil stabilizers such as lichen, fungal, and algal crusts are highly vulnerable to vehicles (Wilshire 1983). The force of rolling wheels on soil can cause compaction, which can have serious, long-lasting effects including decreased water infiltration, increased runoff, and severe erosion problems (Webb 1983).

The tracks of ORVs, especially on erosion-sensitive soil surfaces, form continuous rills, channels, and gullies that can change the speed, timing, quantity, and quality of water flowing across the landscape (Heede 1983, Hinckley et al. 1983). For example, in the Nueces River Basin, Texas, greater erosion was documented in areas with off-road vehicle use, where floodwaters removed and redistributed gravel, than in areas where off-road vehicle traffic was absent (Taylor 2001, Garrett 2001).

Effects on Air and Water

Many types of ORVs release far greater quantities of pollutants than do vehicles not intended for off-road use (Schubert & Associates 1999, Davenport and Switalski 2006). Forest Service researchers have found that some vehicle types vent 25 to 30 percent of their oil and gas in the air unburned (Harrison 1976, The Wilderness Society 2001). Although manufacturers have begun to produce ORVs with four-stroke engines, many ORVs have two-stroke engines, which make a disproportionately high contribution to air pollution. For example, hydrocarbon (HC) emissions from two-stroke engine-equipped motorcycles are about 10 times greater than those from a comparable four-stroke motorcycle on a per-mile basis. The HC emissions for both two-stroke and four-stroke motorcycles are also significantly higher than those from a typical new car. Nationally, recreational vehicles (including snowmobiles) represent approximately 10% of all mobile-source HC emissions and 3% of all mobile-source carbon monoxide emissions (U.S. Environmental Protection Agency 2002).

Use of ORV trails near streams, rivers, and lakes creates a serious water pollution threat. When ORVs ford streams, they stir up bottom sediment, increase stream bank erosion, increase nutrient loads, increase turbidity, and cause vegetation loss in riparian areas (Hammitt and Cole 1987). Vegetation loss may result in increased water temperature,

which in turn increases the metabolic rate, respiration, and oxygen demand of fish and other aquatic species (Kolbe and Luedke 1993). Suspended solids can settle over eggs and fish nests, resulting in lower reproductive rates, and disrupt the food base of insects such as dragonflies (Anisoptera) and damselflies (Zygoptera). At one site unaffected by ORVs in the Nueces River Basin in Texas, numerous indicator species of fish were found that require clean, flowing water and sand and gravel for spawning. These characteristics were absent from a nearby ORV-impacted site, where 79% of species were environmentally tolerant and sensitive fish species were absent (Garrett 2001). In areas with extensive and heavily used ORV trail networks, sedimentation effects may influence entire watersheds (Kuss et al. 1984). Furthermore, tens of millions of gallons of gasoline and motor oil likely enter the soils and waters of our public lands each year, as a result of inefficient combustion and emissions of ORVs (Havlick 2002).

What's Needed

As ORV off-trail riding increases, along with associated demand for more ORV recreational opportunities, the environmental effects of ORV use need to be carefully considered and strategic plans developed for public lands to cope with the conflicts between recreation and environmental protection that will certainly arise. An excellent first step in managing ORVs is the Forest Service's new policy of designating specific trails and roads for ORV use, and prohibiting the vehicles from going off-trail. However, land management agencies also need to ensure that ecological analyses, monitoring, and enforcement plans are implemented in order to identify and respond to the effects of past and future ORV use.

Therefore, we urge the Forest Service and other land management agencies to use the following comprehensive planning process to ensure that new regulations governing off-road vehicle use are based on the abundant peer-reviewed scientific research, and will ensure resource protection. Some of the steps below address important and longstanding policy directives for managing ORVs on public lands contained in Executive Orders 11644 and 11989, which form the basis for federal agencies' regulation and decision-making processes.

- First, land management agencies should undertake the following assessments, either prior to or in the course of developing a travel plan:
  1. A natural resources inventory that describes the distribution and abundance of plants and animals, the location of landscape cover types and habitat features, and the needs of endangered and threatened species and other natural resource concerns.
  2. A survey of existing roads and trails to provide the baseline information needed to understand where ORV riding is most concentrated. Where information is currently missing, surveys should be conducted and added to the database where applicable. Such a survey would help agency personnel recognize the extent to which the landscape has been affected by both legal and unauthorized motorized travel and recreational

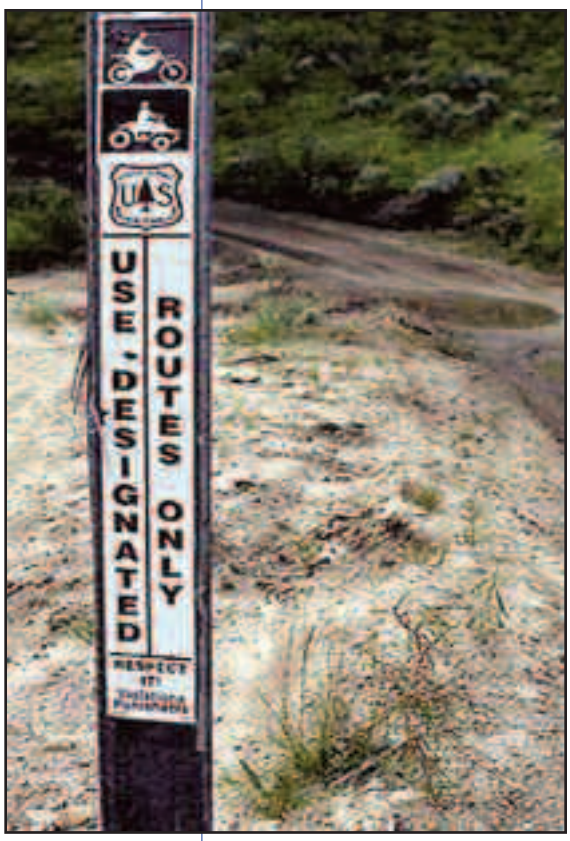


PHOTO COURTESY US FOREST SERVICE

Ecological criteria and sound science should guide the designation of ORV routes on public lands.

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Agencies should permit ORV use only to the extent that monitoring and enforcement are annually funded and properly implemented. Education of the public and self-policing on the part of ORV users can also help ensure the success of ORV management.
▲

use, and which areas may be in need of rehabilitation and possible closure. The survey should not be confused with or labeled as a "baseline travel system," as it often will contain numerous user-created or other undesirable routes that have not been intentionally designed or engineered to accommodate ongoing motorized travel.

3. Habitat fragmentation analyses to ascertain the direct, indirect, and cumulative impacts of ORV trails and roads on wildlife habitat, habitat connectivity, populations, and distribution, and to locate relatively unroaded areas that function as high-quality habitat for many wildlife species. These analyses should include calculations of trail and road densities, edge effects, and core habitat areas, and should use current road and trail data and the latest scientific literature on the impacts of such routes on wildlife and aquatic species.

- The ecological assessments based on the above analyses should be used to determine areas appropriate or inappropriate for ORV use (e.g., requiring closure). This information should also be made available for public review and discussion, and used as an opportunity to gather information from all recreational sectors.

- Finally, agencies should develop ORV access and management plans as well as monitoring programs based on the above inventories, analyses, and public review. Management plans should:
  1. Permit ORV use under conditions that protect natural resources, environmental values (e.g., quiet, landscape character), public safety, and the experience of other public land users (Executive Order 11644).
  2. Include a requirement to analyze new recreational technologies/activities before permitting their use to determine potential negative impacts on the environment and environmental values (e.g., quiet, landscape character).
  3. Designate roads and trails for ORV use through environmental analyses under the National Environmental Policy Act (Executive Order 11644).
  4. Designate ORV routes based on ecological criteria, including but not limited to locating routes to minimize erosion, spread of invasive plants, wildlife harassment, impacts to natural wildlife behavior, and habitat fragmentation (Executive Order 11644).
  5. Decommission and restore unnecessary roads and trails in order to reduce overall road and trail density, and thus reduce habitat fragmentation and disruption of wildlife behaviors and movements (Executive Order 11644).
  6. Protect relatively unroaded areas and Inventoried Roadless Areas from further ORV trail and road development so that these areas maintain their natural ecological processes.
  7. Limit construction of new motorized roads and trails, and if new construction does occur locate the routes carefully to protect sensitive areas from disturbance.
  8. Plan ORV access points wisely. ORV use should be allowed through designated entryways and checkpoints. These access points should be located far away from sensitive areas.
  9. Reduce road widths—the wider a road or trail, the greater the

edge effect will be. Road and trail widths can be reduced by placing logs and rocks along the road or trail, not removing trees, and/or not mowing along the road- or trailside.

10. Ensure that roads and trails are properly signed and maintained.
11. Avoid rest-rotation schemes—rotating ORV recreation from one area to another periodically to allow for rest and recovery spreads negative impacts over larger areas of the landscape.
12. Include a monitoring program to measure short- and long-term ORV and road impacts on forest ecosystems. If monitoring determines that the use of ORVs is causing or will cause considerable adverse effects on natural resources, then the trail or area must be closed immediately until adverse effects are eliminated and measures are taken to prevent a recurrence (Executive Orders 11644 and 11989).

- Agencies should permit ORV use only to the extent that monitoring and enforcement are annually funded and properly implemented. This may require substantially improving law enforcement on public lands. All enforcement recommendations listed below must be implemented together in order to be effective:
  1. Create a law enforcement task force and enforcement plan for each national forest.
  2. Control traffic on problematic roads and trails by restricting use to daylight hours and establishing and enforcing strict speed limits.
  3. Implement a permit system.
  4. Increase penalties for violations and funding for law enforcement.
  5. Institute a volunteer ranger program.
  6. Consider closing trails and roads in unrestricted areas that cannot be adequately patrolled and monitored to prevent ecological damage.
  7. Close trails where off-trail riding continues to be an issue.
  8. Consider incentives for ORV users to self-police each other.

- A key component in the success of ORV management is educating the public as well as users. Studies have shown that most recreationists of all types are unable to recognize ecological impacts (Hammitt and Cole 1987). Two components of education can directly decrease natural resource abuse: 1) information about ORVs—rules, regulations, and users' maps clearly showing where they can and cannot ride; and 2) information about natural resources and the negative impacts ORVs have on them.

- Land managers must recognize the potentially devastatng ecological effects of ORVs, and locate their use only where it is compatible with protecting and conserving public land for future generations.

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