# Section 7

# THE USE OF WINTER ROADS IN FOREST PRACTICES, AND THE RELATIONSHIP WITH ATV USE

**An annotated bibliography**

**Compiled for the Region II Forest Resources and Practices Science and Technical Committee**

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## SUMMARY

The objective of this review is to review the literature on winter roads and impacts from ATV use of forest roads. The exposure of mineral soil adjacent to streams can result in the delivery of sediment to streams and a loss of water quality and fish habitat. Erosion and sediment delivery rates vary with soil types and bank or valley slopes. The duration of erosion and sediment delivery is inversely proportional to revegetation rates (Sparrow et al. 1978, Meyer 2002).


The exposure of mineral soil on winter roads can occur either directly as a result of forest harvest activities or can occur indirectly following forest harvest due to subsequent use of the road corridor by on- or off-road-vehicles. Winter roads are defined in the Alaska Administrative Code as, "roads that can normally support regular logging vehicle traffic only during winter months and that have a load bearing capacity derived from a combination of frost, snow, or ice" (11 AAC 95.900(90)). The direct exposure of mineral soils during forest harvest can occur when the organic mat is removed when clearing the road or fill is used for road construction (photograph). Direct exposure also can occur when the road is used at times when there is not enough snow and frost to protect the underlying vegetation.


The use of ATVs also can result in the removal of the vegetative mat and increase rates of erosion. The number of passes required to remove the organic mat and result in erosion varies with the type of vegetation cover, soil water content, and soil type (Meyer 2002). However, the most resistant types of vegetation can be removed within a very short time. ATV stream crossings have been found to be associated with winter logging roads; however, ATV stream crossings also were associated with other activities that provided an access route such as seismic and utility lines (Weidmer 2002). Forest clearing that provides routes to destinations like hunting or recreational areas will result in an increase in ATV use.

The direct effects of the use of winter logging roads can easily be avoided by maintaining the underlying vegetative mat. The removal of vegetation for road construction adjacent to streams for grade, or to increase freezing rates should be avoided. Crossing locations should be located at sites with low approach slopes so that grade adjustments are not necessary. It has been well established that snow and soil frost can be used to protect underlying vegetation from normal use of winter roads during forest operations. Different sources suggest differing amounts of snow and frost to necessary for ground protection. Ranges vary from 8 to 12 inches of snow and a minimum of 6 inches of frost. It should be recognized that winter roads can only be used for a short time even in good years and that winter roads may not be an option some winters or may need to be closed in the middle of the season to protect the underlying vegetation and water quality.


## REFERENCES


### WINTER ROADS

**Mihalow, Nick 1992. Snow Roads and Ice Bridges for Alaska, A Literature Review. Draft. Dept. of Natural Resources, Division of Forestry.**

Where log hauling on ice roads is necessary, it will begin when underlying ground is frozen sufficiently to support equipment. This requires a minimum of 8 inches of snow and 6 inches of frost

**Ministry of Natural Resources. 2001. Third draft of revisions to environmental guidelines for access roads and water crossings. Ontario, Canada. 76p plus figures.**

- Recognize that winter roads are of short duration and dependent on winter conditions
- Ensure sufficient time for log removal and crossing structures removal before ground softens.
- Locate crossings where approach roads have a grade of 5% or less.
- Construct approaches with compacted snow—do not disturb vegetation or root mass. Where snow limited slash, tops, log bundles used to build approaches.
- Snow thickness 30cm or more.
- Winter bridge standards—temporary bridges and culverts.

**Ott, R.A. 1998. The impact of winter logging roads on vegetation, ground cover, permafrost, and water movement on the Tanana River floodplain in Interior Alaska: Alaska Department of Natural Resources Division of Forestry, Cooperative Agreement AK-DF-A97-RN0006, 10-07-052.**

### OFF ROAD VEHICLES

**Ahlstrand, Gary M, .Susan E. Cantor and Charles H. Racine 1988. Effects of all-terrain vehicle use in the vicinity of Anaktuvuk Pass, Gates of the Arctic National Park, Alaska. USDI National Park Service, Alaska Region. I. Study of Established, Recovered, and New Trail segments Natural Resources Report AR-88/01. Anchorage, Alaska. 114 pp. +**

**Ahlstrand, G. M., and C. H. Racine. 1993. Response of an Alaska, U.S.A., shrub-tussock community to selected all-terrain vehicle use. Arctic and Alpine Research, 25:142-149.***

Vehicle tracks depth increased significantly with increasing passes. Vehicles running on rubber tires created deeper tracks than similar vehicles mounted on continuous rubber tracks. Heavier ATVs usually produced deeper tracks. More traffic more impact. Impacts vary by weight and

type of vehicle. Plants varied in their susceptibility to damage. Dwarf shrubs *Empetrum nigrum* and *Vaccinium vitis-idea* least affected; low shrub *Betula nana* most affected. More impacts with dispersed traffic than with concentrated (temporally) traffic. Results showed sites were most susceptible to disturbance when soil moisture content was high. Maximum vegetation damage can be expected when use occurs during the spring thaw when the thaw depth is shallow and during or immediately after prolonged periods of rainfall when soils are at or near saturation. Care should be taken to leave the organic mat intact and areas with standing water should always be avoided.

**Alaska Department of Fish and Game (ADF&G). 1996. Off road vehicle and snowmachine use in Alaska: a report to the Alaska Board of Game. Division of Wildlife Conservation, Alaska Department of Fish and Game, Juneau. ***

The Alaska Department of Fish and Game should work with users and other interested parties to evaluate the extent to which biological concerns or perceived user conflicts are valid and to develop management plans and strategies to address these issues. The BOG should continue to address use of ORVs and snowmachines within the context of its regulatory process and the limits of its statutory authority. In some areas, expanded use of ORVs has positive effects by distributing hunting pressure over a larger area. ORV hunter and recreational use expanding in 1A, 1C, 2, 5, 8, 9, 11, 12, 13, 14, 15, 16, 20, 23. Unit 5. Yakutat area. ORV trails might have some impacts to moose habitat by changing drainage patterns, thereby influencing willow stands, and erosion from trail system could cause sedimentation of fish streams. Unit 8. Kizhuyak Bay areas near Port Lions (Kodiak). Increasing and spreading use has caused vegetation damage and erosion. Northeast Kodiak Island. Proliferating ORV trails in Chiniak Bay and the northern drainages into Ugak Bay are causing vegetation damage and soil erosion on state and private lands. Some of these trails are impacting sensitive wetland areas. Unit 9. Bristol Bay. Cross country travel by ORVs to reach hunting areas in the King Salmon drainage increased substantially during fall moose and caribou seasons. Naknek-Kvichak Advisory Committee responded by proposing a Controlled Use Area for the eastern portion of the Naknek drainage, restricting the use of ORVs by hunters to designated trails between August 1 and November 30. (implemented by BOF in 1991). This regulation has been effective in reducing vegetation damage prior to freeze-up and has apparently gained support as conflicts between users diminished. Harvest of moose and caribou has not been compromised. Unit 13. ORV use in 13A west of Lake Louise Road has caused visible environmental degradation, but miners rather than hunters may be responsible, at lease initially, for most of the impact. Environmental degradation is primarily a concern for visual quality; there has not been a significant loss of wildlife habitat, although ORV trail systems have expanded. Unit 14. Willow Mountain Critical Habitat Area. The ORV trail systems appear to have grown in number of routes as well as level of vegetation damage since 1990. Unit 16(14?)A North of Petersville Road. Major trails though the bog meadows are becoming several hundred feet wide. The Tule white-fronted goose nests in this area and this ecotype. Potential impacts on the Tule are unknown, but could be important over time. Unit 15. However, with increasing use, there is the potential for undesirable effects such as higher harvest pressure on brown bears, more DLPs (defense of life and property), fewer refugia from hunting pressure, etc. The best approach to addressing this issue is to work with the users, requesting their input on how to minimize adverse effects of expanding ORV use while maintaining the opportunity to use these vehicles for access. Unit 20D. Significant habitat degradation has occurred in the McCumber Creek drainage in southern Unit 20D, however, the degradation is associated with ORV use by miners rather than hunters. Several trails commonly used by hunters with ORVs have portions that have become eroded or degraded in some manner. Although the potential exists for increased habitat degradation in the future…

**Alaska Department of Fish and Game. 1990. Off-road vehicles and hunting in Alaska, a report to the Alaska Board of Game. Alaska Department of Fish and Game, Division of Wildlife Conservation, Anchorage. ***

Recommendations. Actions taken by the Board to avoid or minimize impacts on wildlife should be the least restrictive necessary to achieve the desired result. However, ORV use should not be allowed to significantly affect wildlife resources, their habitats, or other users in an unplanned or uncontrolled manner. Actions the Board may consider include: Limit ORV size, Limit ORV type, Designate open areas or trails. Designate times, Limit numbers of hunters using ORVs by permit. Close areas to use of ORVs for hunting and transporting game. Close areas to use of ORVs. Enlist cooperation of the Department of Natural Resources or other land managers. The trail networks developed by moose hunters traverse virtually all terrain and habitat types. Environmental degradation, including both soil erosion and loss of vegetation, is extensive. This degradation is approaching a level which could be considered a significant habitat loss.

**Baxter, C. V., C. A. Frissell, and F. R. Hauer. 1999. Geomorphology, logging roads, and the distribution of bull trout spawning in a forested river basin: implications for management and conservation. Transactions of the American Fisheries Society 128:854-867.**

Bull trout redd densities and counts per stream were inversely correlated with the density of logging roads and the number of road crossings per catchment. Physical and biological lags between upland disturbance, stream habitat change, and a perceived response in redd counts could exceed 10 -- 15 years, which could complicate monitoring and preclude the success of short-term adaptive management schemes. Additionally, time trends in redd counts may not be statistically verifiable until after a decline has become difficult or impossible to reverse.

**Berry, Kirsten H. 1980. The effects of four wheel vehicles on biological resources. Edited by: Off-Road Vehicle Use: A Management Challenge. Richard N.L. Andrews and Paul F. Nowak (University of Michigan Extension Service) Michigan League. University of Michigan. School of Natural Resources. USDA The Office of Environmental Quality. +**

**Birkby, R. C. 1996. Lightly on the land: The SCA trail-building and maintenance manual. The Mountaineers, Seattle, WA. ***

Failure to plan thoroughly new trails and trail relocations results in more problems, expense, and ultimate frustration that any other aspect of trail work.

**Brown, K. J. 1994. River-bed sedimentation caused by off-road vehicles at river fords in the Victorian Highlands, Australia. Water Resources Bulletin 30:239-250. ***

Rivers 20 and 15 m wide and 0.5 m deep. Sediment is contributed to the river by five major processes: the creation of wheel ruts and concentration of surface runoff, the existence of tracks and exposed surfaces, the compaction and subsequent reduction in the infiltration rate of soils leading to increased surface runoff, backwash from the vehicle, and undercutting of banks by bow wave action. Bow wave alterations to stream banks dependent on size and speed of vehicle. Alterations extended 5 m upstream and 15 m downstream of the ford. Runoff channelized by ORV trail ruts, with runoff at higher velocity than in unaltered areas. Backwash: water draining from vehicle flowing back down the approach road. Backwash could be reduced by gravelling the approach road. The net effect of the processes described above is the formation of a sediment apron at the base of the ford. This apron is largely unaffected by river flow, as it is sheltered by the banks on either side of the approach road. It is only when a vehicle crosses the river that the apron acts as a sediment source, and sediment is resuspended, forming a plume which travels downstream. A sediment plume of fine material caused by vehicles using a ford was capable of traveling several kilometers downstream. Most course material was redeposited within 20 m. Sediment deposition is positively correlated with traffic. Recreational vehicles are responsible, either directly or indirectly, for the addition of significant amounts of sediment into streams.

**Bury, R.L., R.C Wendling, and S.F. McCool. 1976. Off-road recreation vehicles - a research summary 1969-1975. Texas Agric. Experiment Station, Report MP1277, College Station, Texas. +**

**Charman, Daniel J., and Andrew J. Pollard. 1995. Long-term vegetation recovery after vehicle track abandonment on Dartmoor, SW England, U.K. J. Environ. Manag. 45:73. ***

High moorland-blanket bog is most sensitive to traffic and is less able to recover naturally once traffic is halted. In these habitats, closure alone may not be adequate to restore vegetation within a reasonable timeframe, indicating that recovery may never be possible from a simple, non-intervention policy.

**Davis, J.C., and D.B. Ryland. 2002. Upper Susitna ATV stream crossing locations. Technical Report No. DRAFT. Alaska Department of Fish and Game, Habitat and Restoration Division. Anchorage, AK. 17p.**

**Duever, Michael J., Lawrence A. Riopelle and Jean M. McCollom 1986. Long term recovery of experimental off-road vehicle impacts and abandoned old trails in the Big Cypress National Preserve. USDI National Park Service, Big Cypress National Preserve. SFRC-86/09. National Audubon Society, Ecosystem Research Unit. +**

**Duever, Michael J., John E. Carlson and Lawrence A. Riopelle 1981. Off road vehicles and their impacts in the Big Cypress National Preserve. USDI National Park Service, Big Cypress National Preserve . T-614. National Audubon Society, Ecosystem Research Unit, 214 pp. +**

**Duncan, S. H., R. E. Bilby, J. W. Ward, and J. T. Heffner. 1987. Transport of road-surface sediment through ephemeral stream channels. Water Resources Bulletin 23:113-119. ***

A significant amount of road-derived sediments entering ephemeral stream channels are retained within the channels. Coarser sediments are retained at a higher rate than finer sediments. Large woody debris and channel gradient also influence sediment transport.

**Dunn, Allen B. 1984. Recreation effects on forest soil and vegetation: research synopsis and selected bibliography. Clemson University College of Forest and Recreation Resources. Department of Forestry Technical Paper NO. 16. Clemson, South Carolina, 61 pp. +**

**Edwards, R. and D. Burns. 1986. Relationships among fish habitat embeddedness, geomorphology, land disturbing activities and the Payette National Forest sediment model. USDA Forest Service, Payette National Forest. 6pp. +**

**Forbes, B. C. 1992. Tundra disturbance studies I: Long-term effects of vehicles on species richness and biomass. Environ. Conserv. 19:48(11). ***

Two sites in the Canadian High Arctic: After 20 years of unassisted plant recovery both vascular and cryptogamic species-richness were reduced by low-intensity disturbance regimes. Seedling establishment by dicotyledons is lacking in multipass tracks.

**Forest Service 1977. Final environmental impact statement off-road vehicle policy Allegheny National Forest. USDA Forest Service, Eastern Region. USDA-FS-R9-FES-ADM-76-04, 216 pp. +**

**Geological Society of America. 1977. Impacts and management of off-road vehicles Report of the Committee on Environmental and Public Policy. Boulder, CO, 8 pp. +**

**Gersper, P. L. and J. L. Challinor. 1975. Vehicle perturbation effects upon a tundra soil-plant system. In: Effects on Morphological and Physical Environmental Properties of the Soils. Soil Sciences of the Society of America. 39(4):734-744. +**

**Godfrey, P. J., and M. M. Godfrey. 1980. Ecological effects of off-road vehicles on Cape Cod. Oceanus 23(4):56-67. ***

Cape Cod National Seashore: Just one vehicle pass in enough to physically damage plants. Where vegetation is sensitive to vehicle traffic, it is better to have a few well-managed and well-patrolled dune tracks than to have many lightly used trails. Recovery rates depend on topography, soils, and vegetation and can be rapid or on a decadal scale. Physical robustness of plant (e.g., woody v. non-woody) helps determine the degree of initial damage. Method of propagation (vegetative (rhizomes) v sexual (seeds)), soils, and topography determine revegetation rates. Soft, saturated soils are easily rutted. Vegetation may regrow quickly, but ruts may remain. "There can be no doubt that ORVs do environmental damage in just about any ecological setting. The problem is to decide where the least damage will occur, and how much, if any, is acceptable." Natural sites can recover after closures. "ORV traffic must be managed, and it is important that all parties realize that cooperation and control are necessary to prevent continuing damage to coastal ecosystems." Management response: Designated trails to acceptable destinations, Controlled use in upland areas. Closures in ecologically sensitive areas. Construct structures to avoid disturbance to sensitive sites. Education programs through government agencies and ORV clubs.

**Griggs, G. B., and B. L. Walsh. 1981. The impact, control, and mitigation of off-road vehicle activity in Hungry Valley, California. Environmental Geology, 3:229-243. ***

ORV use leads to hillside erosion which is deposited as sediment in streams. Sediment transport correlated with ORV use.

**Harrison, R.T. 1980. Environmental impact of off-road motorcycles. In: Andrews, R.N.L. and P.F. Nowak. Off-Road Vehicle Use: A Management Challenge. pp 266-269. USDA Office of Environmental Quality, University of Michigan. +**

**Hogan, A.W. 1972. Snowmelt delay by oversnow travel. Water Resources Research 8: 174-175. +**

**Hosier, P. 1981. Striking a balance: off-road vehicle use and coastal preservation. Seagrant today, 11(6):10-12. ***

North Carolina Beach. ORV use should be restricted to non-sensitive habitats. ORV use should be seasonally restricted to reduce conflicts with wildlife and other users. Sensitive habitats (e.g., nesting sites) should be clearly marked. Strict prohibition from sensitive habitats. Structures should be constructed where trails must cross sensitive habitats. Regular monitoring of trail system. Fence, post signs, and plant closed trails.

**IMBA (International Mountain Bicycling Association). 2001. Unauthorized Trails: Do they threaten our sport? IMBA Trail News, 14(2):8-9. ***

Future of mountain biking depends on cooperation with land managers.
IMBA opposes building or altering trails or structures without land manager permission

**Johnson, C. W., and J. P. Smith. 1983. Soil loss caused by off-road vehicle use on steep slopes. Transactions of the ASAE (American Society of Agricultural Engineers) 26(2):402-405. ***

Boise Idaho. Soil loss measurements provide data to show environmental effects of extreme soil and vegetation cover disturbance by ORVs on these steep erodible slopes. Steeper slopes show greater soil loss than shallower slopes.

**Kay, J. 1981. Evaluating environmental impacts of Off-Road Vehicles. J. Geogr. 80:10. ***

Wasatch National Forest, Utah. Major impacts of ORVs are lower species diversity, a greater denuded area, smaller amounts of plant litter available for incorporation into the soil, and greater loss of soil through gully erosion. These effects appear to be reversible under a policy of ORV exclusion.

**Kockelman, W. J. 1983a. Management Practices. Pp. 447-494 In Environmental effects of off-road vehicles: impacts and management in arid regions. Webb, R. H., and H. G. Wilshire, eds. Springer-Verlag, New York. ***

Management Practices. Monitor Impacts. Monitoring is a prerequisite to closing and reclaiming.

**Kockelman, W. J. 1983b. Regulations and Education. Pp. 495-515. In Environmental effects of off-road vehicles: impacts and management in arid regions. Webb, R. H., and H. G. Wilshire, eds. Springer-Verlag, New York. ***

Regulations and Education. Consistent enforcement of ORV regulations and penalties is necessary to accomplish the goals of meeting user needs, protecting resources, and avoiding conflicts. Without enforcement and penalties, all other work—resource inventory, designation or zoning, site selection, facility design, management, and regulations—would be for naught. State legislatures, local governments, and federal public-land managers should provide for enforcement of the regulations, such as providing adequate enforcement personnel, techniques, and methods for enforcement; immediate prevention of any further damage; and appropriate penalties.

**Kostielney, J. W. 1998. ORVs and the environment: big impact or not? Erosion Control 5(2):90. ***

ORV review. Attempts to close roads have met with public resistance.

**Leung, Yu-Fai, and J. L. Marion. 1996. Trail degradation as influenced by environmental factors: A state-of-the-knowledge review. Journal of Soil and Water Conservation 51(2):130-136. +**

**Leung, Yu-Fai, Marion, J. L., and Ferguson, J. Y. 1997. Methods for assessing and monitoring backcountry trail conditions: An empirical comparison. In: Harmon, D. ed., Making Protection Work: Proceedings of the 9th George Wright Society Conference on Research and Resource Management in Parks and on Public Lands, March 17-21, 1997, Albuquerque, NM. Hancock, MI: The George Wright Society. pp. 406-414. +**

**Lodico, Norma Jean 1973. Environmental effects of off-road vehicles: a review of the literature. USDI Research Services Branch, Office of Library Services. Bibliography DOI-RSB-73-01. Washington, DC, 111 pp.**

**Luckenbach, R. A. 1978. Impacts of ORVs: An analysis of off-road vehicle use on desert avifaunas. Wildlife Management Institute of North America, 43rd North American Wildlife Conference. Pp. 157-162. ***

SW USA Desert, Review of impacts to birds Management guidelines concentrate ORV use in limited areas. Seasonal closures. Close large tracts of pristine land.

**Leung, Y., and J. L. Marion. 1996. Trail degradation as influenced by environmental factors: a state-of-the-knowledge review. Journal of Soil and Water Conservation 51:130-136. ***

Primary environmental factors affecting trail degradation include climate and geology, which act on each other as well as the intermediate elements of topography, soil, and vegetation. Primary use-related factors include user type, use intensity, and user behavior. Through trail layout and design, managers can minimize trail degradation by selecting routes through more resistant and resilient soil and vegetation types and by avoiding sensitive landforms and topography. (Price, 1983). Through their influence over use-related factors, managers can reduce amount and type of use or modify visitor behavior that contribute to excessive trail degradation (Doucette and Kimball 1990). Finally, through trail construction and maintenance actions, managers can harden trails to sustain use while minimizing water and wind erosion (Proudman and Rajala 1981). Dense trailside vegetation confines the lateral spread of trail users while segments crossing open meadows often widen or split to form multiple treads. The capacity of a trail to sustain recreational use is greatly increased by avoiding routes through areas particularly susceptible to degradation and favoring areas that are resistant to such changes. Most trails were originally designed to serve non-recreational purposes, including logging roads, fire access routes, wagon roads, railroad grades, and access routes to former homesteads or fire towers. Though such routes were designed to be serviceable, resource protection objectives were rarely a concern. Route selection was commonly based on finding the shortest distance between two points or done by individuals who either lacked or did not fully apply knowledge of environmental factors. A common error by managers who inherit such trails has been to ignore such environmental deficiencies in their attempts to control trail degradation. The resulting trail problems are often ignored or addressed through restrictions on trail users and/or increased trail maintenance. Such solutions are often unnecessarily restrictive to trail users, ineffective, and costly. A principle recommendation is that managers conduct careful evaluations of all trail degradation problems to identify environmental deficiencies. Where indicated, such problems should be resolved through trail or segment reroutes, or through additional engineering. Maintenance is important. Factors: Trail slope, trail side slope, trail alignment, slope position, proximity to water, soil texture, soil type, soil moisture, infiltration capacity, stoniness, roughness.

**Marion, Jeffrey L. and Lawrence C. Merriam. 1985. Predictability of recreational impact on soils. Soil Science Society of America Journal 49(3):751-753.**

**Marion, Jeffrey L. 1994. Trail conditions and management practices in the National Park Service. Park Science 14(2):16-17.**

**Marion, J. L. 1994. An Assessment of Trail Conditions in Great Smoky Mountains National Park. Research/Resources Management Report. Atlanta, GA: USDI National Park Service, Southeast Region.**

**Meyer, K. G. 2002. Managing degraded off-highway vehicle trails in wet, unstable, and sensitive environments. Tech Rep. 0223-2821-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 48p.**

**Miller, P. 1970. Off-road recreational vehicle composite. Case Study No. XVI pp. 730-767 In: Becking, R. W., et al. 1970. Public land policy and the environment. Volume 3. Part II (cont'd): Environmental problems on the public lands. Case studies 9 through 17. Rocky Mountain Center on Environment, Denver. ***

California. Enforcement of the (BLM management plan) has been impossible because of lack of manpower. Cooperation of vehicle clubs has been obtained but the clubs only represent about 20% of the users. 70% of visitors do not heed signs restricting vehicle traffic. On BLM land, a minimal management plan restricted off-road travel to a specified area and the marking of one 14-mile trail. Due to lack of power to enforce the regulations, the plan has only been about 30% effective in controlling vehicle traffic. Because of lack of authority, manpower and funds, BLM relied largely upon education of users through club organizations which unfortunately reach only a minority of vehicle enthusiasts. Conflicts between vehicles and other users on USFS California lands first became serious in the late 1950s. To date, two kinds of conflict have brought about these closures: 1) conflict with watershed protection arising from erosion damage (1st closure in 1958; Sierra National Forest); 2) conflict with vehicles and other recreational uses such as hiking and horseback riding (1st closure; Los Padres National Forest 1961). A definite effort has been made to work with vehicle clubs in the repairing and rerouting of trails. The USFS states that the USFS shall prescribe the route, and members of vehicle clubs shall supply free labor to build improvements. In forested areas, it is difficult to leave roads, use tends to be confined to established trails. In mountain meadows there has been serious damage. Erosion is considered the most serious hazard associated with vehicle use. The soils of meadows are generally fine-textured and alluvial. Many meadows are wet all or part of the year; in this condition they are highly susceptible to rutting. Nearly all meadows contain running water for at least part of the year, and often trails will cross streams a number of times. After one rut is produced, there is a tendency for drivers to “fan-out” to avoid getting stuck. Streams are muddied, banks are broken down, and in general the natural process of erosion is greatly accelerated. If damage were allowed to go to an extreme, streams could even be induced to change their course. All of these effects reduce water quality and destroy protecting stream bank vegetation. In the higher and wetter meadows, vehicle tracks can disrupt the distribution of standing water and alter centuries-old patterns of vegetation. Dense chaparral is nearly impenetrable, even on foot, so that vehicle travel is limited to roads, trails, recent burns or firebreaks. The latter are 10-12 foot swaths bulldozed through the vegetation and along the mountain ridges to contain wildfires. These firebreaks are temporary and would quickly revegetate by sprouting. However, because of their steep rugged topography, they are popular with cyclists and continued use prevents revegetation. Paths other than firebreaks have been used for hill-climbing with similar results. Assuming that complete exclusion of vehicles is an impractical solution, the alternative would seem to involve identification of fragile areas and closure to vehicle travel before damage occurs.  Enough is known already to make it obvious that some kinds of vegetation and soils are too fragile to withstand use.  These areas could be closed or closely regulated.  Other areas which are less fragile could be maintained open on the present "watchful waiting" policy.  This kind of procedure is not unprecedented.  Vehicle operators are, of course anxious to have as little regulation as possible.  But Forest Service experience has shown that at least the organized users are willing to accept regulation if they can see the need. California.  Enforcement impossible because of lack of manpower.  Cooperation of vehicle clubs was obtained but clubs represented only about 20% of the users.  Estimate that about 70% of visitors do not heed signs which restrict travel.  Impediments to plan implementation are:  lack of authority, manpower, and funds.  Attempts to regulate travel by signs have failed to prevent damage.  Forest Service policy is that the Forest Service shall prescribe the route, and members of vehicle clubs shall supply free labor to build improvements.  Barricades are largely ineffective at discouraging travel on firebreaks.  Wooded areas are not the main problem area.  Especially in the mountains, it is difficult to leave roads, and environmental effects tend to be confined to established trails.  In treeless mountain meadows there has been serious damage.  The soils of the meadows are generally fine-textured and alluvial.  Many meadows are wet all or part of the year; in this condition they are highly susceptible to rutting.  Nearly all meadows contain running water for at least part of the year, and often trails will cross streams a number of times.  After one rut is produced, there is a tendency for drivers to "fan-out" to avoid getting stuck.  Streams are muddied, banks broken down, and in general the natural process of erosion is greatly accelerated. If damage were allowed to go to an extreme, streams could even be induced to change their courses.  All of these effects reduce water quality and destroy protecting stream bank vegetation. In the higher and wetter meadows, vehicle tracks can disrupt the distribution of standing water and alter centuries-old patterns of vegetation.  Trails created for other purposes (e.g., firebreaks), which would otherwise revegetate quickly.  Their use by ORVs prevents revegetation. Management, Identification of fragile areas and closure to vehicle travel before damage occurs. Enough is already known to make it obvious that some kinds of vegetation and soils are too fragile to withstand use.  These areas could be closed or closely regulated.  Vehicle operators are anxious to have as little regulation as possible.  Forest Service experience has shown that at least the organized users are willing to accept regulation if they can see the need.  Education. Enforcement.

**Mooney, P. 2001.  Yakutat forelands fish habitat and ATV assessment.  Alaska Department of Fish and Game, Habitat and Restoration Division, Sitka, Alaska.  65p.**

**Nakata 1983 (in Webb and Wilshire). ***

Off-Road Vehicular Destabilization of Hill Slopes:  debris flows.  Erosion from ORV trails ended in stream courses.

**Price, M. F. 1983. Management planning in the Sunshine Area of Canada's Banff National Park. Parks 7:6-10. ***

Walking trails: Improve quality of existing trails to keep people from straying. In particular, the number of parallel trails at any point in the trail system should be reduced to a minimum, and then stabilized. This requires the transplanting of vegetation from between the existing parallel trails, and the incorporation of drainage structures, to leave one principal trail. Education: fragility of alpine areas and susceptibility to damage as a result of human use. Monitoring program: Any management strategy, no matter how complete the information on which it is based, must contain the capacity for improvements, based on assessments of the effectiveness of the strategy. Through trail layout and design, managers can minimize trail degradation by selecting routes through more resistant and resilient soil and vegetation types and by avoiding sensitive landforms and topography.

**Racine, C. H., and G. M. Ahlstrand. 1991. Thaw response of tussock-shrub tundra to experimental all-terrain vehicle disturbances in South-central Alaska. Arctic 44:31-37. ***

Wrangell-St. Elias National Park tussock-shrub tundra. ORV impacts vary by type, season, intensity of use, and temporal distribution. If possible, traffic should be concentrated in time rather than dispersed throughout the thaw season.

**Reid, L. M., and T. Dunne. 1984. Sediment production from forest road surfaces. Water Resources Research. 20:1753-1761. ***

A heavily used road segment contributes 130 times as much sediment as an abandoned road.

**Rinella, D.J., and D.L. Bogan. 2003. Ecological impacts of three lower Kenai Peninsula, Alaska, ATV stream fords. Environment and Natural Resources Institute. Anchorage, AK. 34pp.**

**Ross, J. B. 1991. Impacts of All-Terrain Vehicles on bogs of the Cape Breton Highlands, Nova Scotia, Canada. Proc. Int. Conf. On Science and Management of Protected Areas, Nova Scotia, Can (Elsevier) P. 533. ***

The results showed that ATVs were responsible for decreased soil moisture, vegetation loss, and increased bulk density of the soil. Recommended that ATV use be restricted from the bogs, and controlled through an integrated management plan including education, recreational planning, and limited legislation.

**Slaughter, C.W., C.H. Racine, D.A. Walker, L.A. Johnson, and G, Abele, 1990. Use of off-road vehicles and mitigation of effects in Alaska permafrost environments: a review. Environmental Management 14:63-72. +**

The authors review the use and mitigation of effects of ORVs in Alaska's permafrost region. They describe the increase in ORVs in Alaska since the 1960s and their importance in subsistence communities. They cover factors affecting impacts such as permafrost, vegetation, vehicle weight and ground pressure, traffic, season, frequency, and operator practices. They go on to review management options such as regulation, rerouting trails, surface protection and operator training.

**Sparrow, S. D., F. J. Wooding, and E. H. Whiting. 1978. Effects of off-road vehicle traffic on soils and vegetation in the Denali Highway region of Alaska. Journal of Soil and Water Conservation, 33:20-27. ***

Changes in soil morphology in surface horizons, soil compaction, denuded vegetation, grasses and sedges first plants to revegetate abandoned trails. Greatest soil damage occurred in poorly drained areas or on slopes with loose, gravel-free soils highly susceptible to erosion. Least damage occurred on soils containing high amounts of gravel or cobbles. The wettest areas were often the most disturbed parts of trails, especially when subjected to heavy use. Soils in wet areas usually have a thick surface layer consisting of moss and undecomposed organic materials. This organic layer insulates the soil against temperature extremes, absorbs water, and cushions the soil from the direct action of vehicle tires and tracks. However, repeated ORV traffic destroys this protective mat. The churning and crushing action of vehicles causes physical grinding of the surface organic materials and mixing with the underlying mineral soil. These soils often become saturated with water, which ponds on the surface, resulting in a quagmire. ORV drivers often try to circumvent these wet areas, gradually increasing the width of the trail. Most trails in the Denali Highway region were not planned. They formed as a result of repeated use by ORV users concerned only with finding the shortest or easiest route to a certain destination. Much of the damage could have been minimized had the trails been planned so as to avoid areas most susceptible to disturbances. Such trails should follow ridgetops when possible. Boggy areas and side slopes with highly erodible soils should be avoided.

**Sparrow, S. D., F. J. Wooding, and E. H. Whiting. 1978. Effects of Off-Road Vehicle traffic on soils and vegetation in the Denali Highway region of Alaska. J. Soil and Water Conserv. 33:20. ***

Ditto all earlier Sparrow observations.

**Tuttle, M. and G. Griggs, 1987. Soil erosion and management recommendations at three state vehicle recreation areas, California. Environmental Geology and Water Science 10(2):111-123. +**

The authors found 10-25 fold increases in sediment yield on ORV-impacted landscapes relative to nearby undisturbed basins in an arid region of California.

**U.S. Department of Agriculture, Forest Service, Stanislaus National Forest. 1999. Motor vehicle travel management: forest plan direction. +**

The Stanislaus National Forest developed a Motor Vehicle Travel Management Plan in 1998 restricting OHV use in certain management areas (wilderness, wild and scenic rivers) and developing it in others (general forest, experimental forest). Appendix A outlines a trail condition rating whereby ORV trails are placed into three categories of green (meets standards), brown (need maintenance) and orange (needs major attention). These ratings are based on such characteristics as water drainage, trail-rut depth, resource conflict, and off-route use and vegetation damage.

**Van der Merwe, D., and D. van der Merwe. 1991. Effects of off-road vehicles on the macrofauna of a sandy beach. South African Journal of Science 87(5):210-213. ***

Impact on macrofauna on a sandy beach. Impacts vary by species and may be dependent on morphology and behavior.

**Van Patten and Kinney 1999. Assessment of ATV trails on Kodiak Island. ***

Intent was to develop a preliminary assessment of the impact of expanding ATV use on the soil, vegetation, water, aesthetics, and related resources of Kodiak Island. Soil is probably the most affected resource on the landscape due to increased use of the trail system. In the areas surveyed, soils in their natural undisturbed state exhibited very little erosion.

**Webb, R. H., and H. G. Wilshire. 1983. Environmental effects of off-road vehicles: impacts and management in arid regions. Springer-Verlag, New York. ***

**Webb, R. H., H. C. Ragland and D. Jenkins 1978. Environmental effects of soil property changes with off-road vehicle use. Environmental Management 2(3):219-233.**

**Weidmer, M. 2002. Lower Kenai Peninsula summer off-road vehicle trail stream crossings. Technical Report No. DRAFT. Alaska Department of Fish and Game, Habitat and Restoration Division, Anchorage, AK. 23p.**

Twenty two percent of the stream crossings located on the southern Kenai Peninsula were associated with logging roads. A large percent were a combination of logging roads and seismic lines. Seventeen percent were associated with winter logging roods. Difficult to determine whether the ATV crossings were due to the logging road or the seismic lines. IN general the desire and ability to travel wan the main influence on ATV use of trails.

**Wilshire, H. G., S. Shipley, and J. K. Nakata. 1978. Impacts of Off-road vehicles on vegetation. Transactions of the 43rd North American Wildlife and Natural Resources Conference. Wildlife Management Institute. Washington, D.C. ***

ORV use has direct and indirect effects on vegetation. Direct: Sheer stress parallel to the surface. Compressive stress normal to the surface. Indirect: undercutting root systems. Erosion of off-trail areas, Burial by displaced sediments, Physical modification of the soil, Removal of fertile top soil. Management: “The current practice of designating areas for ORV use without any land use or soil conservation planning or management within those areas assures maximum rates of deterioration.”

**Wilshire, H. G., J. K. Nakata, S. Shipley, and K. Prestegaard. 1978. Impacts of vehicles on natural terrain at seven sites in the San Francisco Bay area. Environmental Geology, 2:295-319. ***

Lost plant cover, change in soil properties (surface strength, bulk density, soil moisture, temperature range, organic carbon). Access to areas with taller vegetation is commonly gained along little-used or abandoned roads, utility corridors, fire trails, or logging trails. Unauthorized expansion of trails has been difficult to control even with on-site supervision because of the lack of natural barriers to vehicular entry. Measured erosion: sediment from trails end up in streams.

**Wooding, F. J., and S. D. Sparrow. 1978. An assessment of damage caused by off-road vehicle traffic on subarctic tundra in the Denali Highway area of Alaska. U. S. Forest Service Recreational Impact on Wildlands Conference. Pp. 89-93. ***

ORV traffic damage to vegetation and soils along the Denali Highway. The degree and type of impact was dependent on certain soil and terrain characteristics, plant habitat type, type of vehicle, and time and amount of use. Amount of traffic, plant habitat type, and soil stability properties are the most important factors influencing the degree of plant injury. Soil depth, texture, and drainage are the most important factors influencing the impact of traffic on soils, although slope, vehicle type, vegetative cover, and the amount and time of use can be significant. Heavily used trails are completely denuded of vegetation, less-used trails still have vegetation Between the tracks. All ORV traffic causes some injury; under favorable conditions, however, the injury to the low-growing vegetation as a result of a single pass is usually slight to moderate and the plants recover without any long term effect. Taller shrubs, such as willow and shrub birch, are more susceptible to damage than the low-growing plants. Sedges appear to be most resistant to sustained ORV traffic. Time and type of traffic can be an important factor influencing both soil and plant damage. Many soils become unstable when wet, at spring break-up of during a rainy period, for example. A single pass with a vehicle may cause deep ruts in the soil and kill the vegetation. Very little effect would be noticed if the soil were in a dry or frozen state. Conventional wheels usually cause deep ruts and more complete vegetation removal than do track vehicles. Track vehicles cause deep ruts only under very unstable soil conditions. However, the total area affected is greater with track vehicles than with conventional wheels. Poorly drained soils are often the most damaged soils in the trails, especially if subjected to heavy use. These trails usually have a thick mat of moss and undecomposed organic matter on the surface. This thick cover acts as an insulator that protects the soil from temperature extremes. The soil usually does not thaw below a few centimeters, even during the warmest summer months. The protective covering of organic material helps cushion the weight of passing vehicles. It also acts as a sponge and absorbs water. When this mat of organic material is destroyed by repeated traffic, the soil absorbs more radiation, warms faster, thaws faster and deeper during the summer and usually becomes soggy. Also, the warming and tilling effect of vehicles churning the soil causes an increase in the decomposition rate of organic matter. This, in combination with compaction, reduces the soil porosity. With the absorptive organic layer missing, water becomes ponded and the area becomes a quagmire. A major problem with many trails is that in trying to avoid the quagmire caused by previous use, ORV drivers widen the trail. Repeated traffic gradually increases the width of the trail and the quagmire until it may become 20 to 30 m wide. Soils which are gravelly or cobbly or very shallow soils which have a good gravel or cobble base are less susceptible to erosion than deep, gravel-free soils. However, vegetation on shallow, gravelly, or cobbly soils is more subject to injury than on deeper, well drained soils because it is growing in a more stressful environment and has a weaker root system. Recommendations: As it is unlikely that ORV traffic will be eliminated, certain preventive measures can be implemented to minimize its impact. To encourage ORV drivers to use the main trail rather than making several branches, all but one main entrance to each trail from the highway should be closed and the closed trail revegetated. In some instances where trails pass through areas with soils which are highly susceptible to damage, trails may need to be rerouted. If trails are rerouted, or if new trails are built, they should follow ridgetops and avoid, as much as possible, areas which are steep, boggy, or have erodible soils. In many cases, it may not be feasible to reroute existing trails to avoid all areas that are susceptible to soil damage. Where trails pass through bogs, the widening of the trail should be prevented. In extreme cases of soil damage, diverting water flow or building corduroys may be necessary. In areas where severe erosion has already begun, erosion control measures should be taken as quickly as possible. Revegetating the areas with sod-forming plants is often sufficient but where gullies are forming, damming with bales of straw, brush or logs will likely be required. More research is needed to determine the best methods and materials to use for revegetation and erosion control.

**Wyatt, R. 1988. Implications of illegal off-road vehicle activity on the Cherokee Wildlife Management Area, Unicoi County, Tennessee. Proceedings of the Annual Conference of Southeastern Associations of Fish and Wildlife Agencies 42:533-539. ***

Tennessee; Cherokee NF. Enforcement, Public awareness through media, Trails closed unless posted open, High cost per acre ($800) in areas of active management, Wildlife mortality/disturbance (crushing). Management response: Involvement of ORV users to help maintain an existing trail, Trail designation, Monitoring of trends in habitat damage.

**Yarmoloy, D., M. Bayer, and V. Geist. 1988. Behavior responses and reproduction of mule deer, *Odocoileus hemionus*, does following experimental harassment with an all-terrain vehicle. Canadian Field-Nat. 102:425-429. ***

Study of mule deer response to ATV harassment. Limited harassment by ATV drivers altered mule deer behavior and reduced reproductive rates.

* Indicates annotated reference provided by Michael Weidmer, Alaska Department of Fish and Game, Sport Fish Division, Anchorage, Alaska.
+ Annotated reference from Mooney 2001.