

**Environmental and Social Effects of ATVs and ORVs:
An Annotated Bibliography and Research Assessment**

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Summary

This report provides an annotated bibliography of published research related to the environmental and social effects of ATVs on public and private lands. Citations were gathered in a comprehensive literature review of published research reports and peer-reviewed scholarly writing, and from a review of internet sources. Key findings from the research are synthesized and evaluated, and suggestions for future research are provided.

A wide variety of environmental and social impacts are documented in the research literature, including those related to soil erosion and trail degradation; vegetation; water and air quality; noise; wildlife and fish; and social conflicts among different types of recreation user groups. Key findings can be summarized as follows:

General: Regardless of vehicle type (ATVs, ORVs, snowmobiles), research generally shows very similar impacts; differences in impact level are due more to intensity of use or use characteristics, in combination with the level of fragility of the affected environment.

Air Quality: Studies of air quality impacts are limited, and often focus on the emission effects of snowmobile operation. Findings show that emissions tend to exceed human health standards. Further research about the effects of ATV emissions on humans and other species, and for general air quality, is needed.

Soil and Vegetation: Soil and vegetation impacts are widely discussed in the literature, and obvious to even casual observers. Soil compaction and the shear forces of motorized vehicles create mud holes and gullies that alter hydrologic patterns and intensify erosion. More studies are needed to quantify the amount and extent of soil loss attributable to ATV use in the Northeast.

Trails: Trail erosion and compaction caused by off-road and all-terrain vehicles reduce the quality of recreational trails and require enhanced management action to develop and maintain safe, usable trails. Specific studies are lacking in the New England region.

Wildlife: Wildlife impacts have been primarily studied in relation to Western habitats and have often focused on snowmobile use. Wildlife are negatively impacted by the presence and noise of ATVs, ORVs, and snowmobiles, although some mammals (deer, for example) may become, over time, habituated to these vehicles. Snow compaction also affects the survival and activities of small mammals. Studies of ATV impacts on wildlife in Eastern settings appear to be limited.

Forests: ATV use has been found to widen and rut forest roads, and to increase the sediment load to streams which may threaten fisheries. ATVs and ORVs offer access to resource areas that are typically less accessible and more remote.

Recreation: ATV, ORV and snowmobile use often conflicts with non-motorized uses, such as hiking and cross-country skiing. Additionally, noise and intrusion of the modern world into nature often compromises the enjoyment of many user groups. The numbers of motorized recreationists, and their intensity of use, also results in environmental degradation that reduces the pleasure of non-motorized visitors, potentially resulting in displacement of the non-motorized users.

Snowmobiles: Studies show that snowmobiles compact insulating layers of snow and thus compromise the habitat of mammals living below the snow layer. Since snowmobiles share the same noise characteristics as ATVs and ORVs, they may put undue stress on large ungulates, including moose and deer.

Introduction

The use of all-terrain vehicles (ATVs) for recreation and other outdoor activities is a relatively recent phenomena, extending primarily across the last three decades. In the United States, the intersection of two factors – the expansion of participation in outdoor recreation as “Baby Boomers” became young adults, and development of technologies leading to new forms of motorized and non-motorized transport – combined to produce a growth industry for ATVs. According to a report produced jointly by the Maine Department of Conservation and the Maine Department of Inland Fisheries and Wildlife (1989: 6), “ATVs have been sold or manufactured in the United States since 1971. In 1982, approximately 750,000 were in use; the number tripled to more than 2.5 million four years later. ATVs are sometimes operated for their utility value, especially on farms or woodlots; however, the greatest use by far is recreational.”

Definitions

One of the difficulties associated with understanding the use and impacts of ATVs stems from lack of clarity in defining the term and its related concepts, off-road vehicles (ORVs) and off-highway vehicles (OHVs). The Vermont State Statutes relating to ATVs are located in Title 23: Motor Vehicles, Chapter 031: All-Terrain Vehicles, Sections 3501-3518. The definition provided in that source describes all-terrain vehicles as, “any non-highway recreational vehicle, except snowmobiles, when used for cross-country travel on trails or on any one of the following or a combination thereof: land, water, snow, ice, marsh, swampland, and natural terrain.”

The Vermont statute definition is similar to that used by the Maine Department of Conservation and the Maine Department of Inland Fisheries and Wildlife (1989: 7), which defines an ATV as a “motor driven, off-road recreational vehicle capable of cross-country travel on land,

snow, ice, mud, swampland or other natural terrain. [These include] but [are] not limited to, a multi-track, multi-wheel or low pressure tire vehicle; a motorcycle or related 2-wheel, 3-wheel, or belt-driven vehicle; an amphibious machine; or other means of transportation [not including snowmobiles] deriving motive power from a source other than muscle or wind.”

In contrast to the Vermont statute, some authors include snowmobiles in their definitions. For example, Sheridan (1979: Intro-v) suggested using the term ORV “to cover all motorized vehicles which travel off-road for recreational purposes – motorcycles of various sorts...four-wheel drive vehicles such as Jeeps, Land Rovers, or pickups, snowmobiles, dune buggies, and all-terrain vehicles.” Focusing primarily on wildlife impacts, Petula (1977: 377) also adopted the position that ORVs should include “mainly motorcycles and dune buggies but also snowmobiles.” Nicholes (1979: G.E200) made a distinction between “off-highway vehicles” and “off-road vehicles,” writing, “Off-road vehicles (ORV) utilize a resource in an unobstructed pattern. Some of the areas that can be labeled ORV use areas are: play parks, competitions facilities, cross-country travel not utilizing roads or trails; and off-highway vehicles (O[H]V) utilize lineal corridors such as graded dirt roads, ungraded roads, trails, paths, etc.”

The research literature cannot be easily or precisely segmented into studies about ATVs, ORVs, or OHVs. Instead, two types of research prevail: (a) studies comparing impacts made by different types of motorized or non-motorized uses, and (b) studies evaluating the impacts of motorized recreation generalized across vehicle types. Examples of the first type include comparisons between motorcycle impacts and impacts made by horses or hikers, and effects of four-wheel drive trucks on specific terrain and landscape conditions. Examples of more generalized impacts studies include those assessing the disturbance effects of motor vehicle noise on elk behavior, for instance, and studies of trail erosion patterns under increasing motorized

(ATV or ORV) use. The general conclusion from most studies seems to be that ATVs and ORVs produce similar kinds of impacts, with variation in impacts related primarily to the intensity of use exhibited by often-increasing numbers of visitors, in relation to the fragility of landscapes used for the activity.

It should be noted that snowmobiles – thought by many to create fewer environmental and social impacts by virtue of their use on a ground-protecting cover of snow – have received increasing attention from researchers in the last two decades. Available research suggests that snowmobiles have generally similar effects as ATVs and ORVs, though the impacts of ATVs, ORVs, and snowmobiles, are manifest differently on resource places. For example, impacts on soils vary by type of vehicle, but impacts on wildlife, air quality, user conflicts, and forest vegetation are similar.

Definition problems create research problems: studies are not comparable, so research results are not cumulative. Problems in definitions also have practical implications. Resource managers must involve relevant stakeholders and interest groups in public decision making, and that is difficult if some groups are (or feel) left out because their type of vehicle is disallowed under given definitions. Measuring activity participation and impact levels is also problematic if some kinds of vehicular activities are defined as being beyond the purview of an agency – even if those activities typically occur on public lands. Definitions that lack comprehensiveness also exclude certain kinds of users from public debates, while simultaneously giving power to others, thus stimulating group conflicts and raising charges of preferential treatment by agencies. One basic need of resource management agencies is to understand the types and characteristics of motorized uses and users, and the ways in which these users define their activities, values, and ties to the land, before policy-making proceeds.

Notes about Literature/Web Search

The literature and web reviews conducted for this project show that a large body of analytic studies arose from research conducted in the 1970s to examine the environmental and societal impacts of ATVs. During that time, recreational use of ATVs was rapidly increasing, and concerns about environmental impacts and user conflicts were intense. Since the late 1970s, though, a more general interest in ATVs and ORVs has emerged in both scholarly and public arenas, and, at the same time, the research focus has shifted towards more specialized topics (for example, snowmobile use and effects).

The literature review indicates that much of the published scholarly research about ATVs and ORVs has focused on their use and impacts in arid regions of the American Southwest where the climate allows year-round use and where impacts in fragile desert environments are severe, obvious, and long-lasting. Specific research about ATV and ORV use and impacts in northern ecosystems (particularly in the Northeast U.S.) has been quite limited, although some studies exploring the impacts of snowmobile use in northern climates and more temperate regions of the country are available. The report attempts to focus on published research literature most relevant to Vermont, and so, much of the literature that focuses only on ATV and ORV use and impacts in arid regions has been intentionally omitted.

References included in the report are sorted by types of impacts, though many studies cut across impact areas. The category of “Comprehensive Studies and Overviews” includes the broadest studies of multiple impacts, while other studies have been categorized based on their dominant impact topic. Each category is introduced with a short summary describing the topic and findings. A section discussing “Future Research” is included at the end of the report.

Comprehensive Studies and Overviews

The research literature about ATV and ORV use and effects includes papers that are comprehensive and/or broadly-focused. Examples of these include conference proceedings, broad overviews, discussion papers, and reviews that analyze a variety of types of impacts. Such writings cannot easily be subdivided into specific impact categories, so are included below as “Comprehensive Studies and Overviews.”

Andrews, R.N.L. and P.F. Nowak. 1980. Off-Road Vehicle Use: A Management Challenge . Ann Arbor, MI: University of Michigan Extension Service.

This edited volume is one of the most -frequently cited sources of literature on the ORV phenomenon. Chapters represent proceedings of a 1980 conference on recreational use of ORVs. Authors discussed use and impacts of ORVs, and management successes and challenges. User and non -user viewpoints are included and research needs are outlined. Though outdated, two tables in Appendix compare state laws related to trail bike use and off-road programs in general.

Baldwin, M. 1973. The Off-Road Vehicle and Environmental Quality . Washington, D.C. The Conservation Foundation.

This comprehensive study examines vehicle profiles (snowmobiles, trail bikes, dune buggies, and all -terrain vehicles), the effects of these vehicles for noise, damage to trails and vegetation, impacts on fish and wildlife, and recreation conflicts (though most impacts were related to snowmobile use, not to use of the other vehicles noted). Specific terrestrial impacts include soil erosion, trail widening and gullying, siltation of streams, and devegetation. Recreation conflicts are associated with noise, dust, and environmental degradation that impair non -motorized users’ enjoyment of their recreational experience.

Belknap, L. K. 1986. “Off Highway Motorcycles.” Pp. Activities 19 -29, in: A Literature Review. The President’s Commission on Americans Outdoors. Washington, D.C.: U.S. Government Printing Office.

This literature review cites several sources for impact information; impacts include soil compaction and displacement, noise conflicts with other users, wildlife disturbance during mating seasons, wildlife and livestock harassment, and the possibility of effects on biogeochemical aspects of water and aesthetics of water quality. Belknap considers off -highway motorcycles to include two-wheel machines used for trail riding and competition, all-terrain vehicles (three and four -wheel vehicles strictly for off-road use), and dual-purpose motorcycles.

Bleich, J.L. 1988. "Chrome on the Range: Off-Road Vehicles on Public Lands." *Ecology Law Review* 15: 159-187.

Discusses issues of ORVs (motorbikes, four-wheel drive jeeps and pickups, campers, and dune buggies), including benefits and costs of their use, and examines the regulatory responses. Also includes a case study from Cape Cod National Seashore. Specific impacts noted are erosion, destruction of vegetation, wildlife disruption, and emissions. The author describes how public land managers have mistaken the "displacement of traditional recreationists by ORV users" (p.163) as a decreased demand for these activities and have allocated more resources to the ORV users.

Lodico, N. J. 1973. The Environmental Effects of Off-Road Vehicles: A Review of the Literature. Washington, D.C.: U.S. Department of the Interior, Office of Library Services, Research Services Branch.

This literature review looks at scientific papers, reports, meetings and conferences, and periodicals to determine ORV effects on vegetation, animals and soil, recreational conflicts, and noise. Dirtbikes were noted as causing compaction and erosion, especially on steep slopes, that can be responsible for preventing seed germination. Since their use coincides with the nesting times of birds, noise from the bikes may cause nest desertion. Due to conflicts with other trail users, it was recommended that motorized recreation be kept separate from all other types. The author also expressed concerns about ATV, snowmobile, and four wheel drive vehicles and their effects, all of which were similar to impacts from dirtbikes.

Petulla, J.M. 1977. "The Impact of ORVs." Pp. 377-378, in: American Environmental History. San Francisco, CA: Boyd and Fraser.

Author includes brief review of ORV impacts, including devegetation, erosion, gullyng, creation of large dust plumes, disturbance to wildlife, and damage to archeological sites.

Sheridan, D. 1979. Off Road Vehicles on Public Land. Washington, D.C.: Council on Environmental Quality.

This comprehensive report by David Sheridan is one of the most commonly cited sources on the subject of ORV impact. Part One of the report discusses the background of ORV users and their machines, and considers the environmental and social impacts that they are causing. Seven case studies are examined to provide specific examples of impacts. Part Two describes ORV policy at the federal level, and assesses strategies needed to strengthen land managers' authority. An annotated bibliography is included at the end of the report; it cites the major research that had been done on ORVs and their impacts. (A complete copy of the Sheridan report is included in the Appendix to this report.)

Vancini, F.W. 1989. Policy and Management Considerations for Off Road Vehicles: Environmental and Social Impacts . Ithaca, NY: Cornell University.

The author discusses issues of natural resource destruction and social conflicts associated with ORV use. Impacts include, but are not limited to “compaction and disruption of surface soil; destruction and dispersal of soil stabilizers; reduction of infiltration capacity; increased frequency and intensity of runoff; and an increase in soil erosion due to the loss of plant life resulting in the accelerated removal by runoff or the accelerated movement of soil by wind” (p. 3). The author notes that the primary complaint among non-motorized users is that the noise of ORVs destroys the solitude of natural settings. Some suggestions for reducing impacts include expanded information and educational offerings for ORV users and developing facilities and management policies that are better suited to ORV needs.

State and Federal Policy Analyses/Case Studies

Policy analyses related to ATV and ORV use and issues are sometimes available from federal or state sources. These may take the form of planning and management review papers, or specific case studies conducted for a resource management agency. Five examples (three from the Northeast) are discussed below.

Dame, J.K., and W.R. Mangun. 2000. “Interjurisdictional Issues of Off-Road Vehicle Use on Public Lands: The Need for Uniform but Flexible Guidelines.” Abstract, Pp. 75-76, in Book of Abstracts: 8th International Symposium on Society and Resource Management , Bellingham, WA. Portland, OR: USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-497. June.

Short abstract of verbal presentation recommending that a set of “uniform guidelines” be used in public lands management of ORV recreation uses. Noting that recreationists using ORVs on public lands increased from 21 to 38 million between 1982 -1992 (p. 75), the authors argued that current policies are contradictory and unduly influenced by special interest groups; moreover, disputes about impacts and use restrictions are likely to increase as forest management plans become due for updating.

Maine Department of Conservation and Maine Department of Inland Fisheries and Wildlife. 1989. A Report and Recommendations on Maine’s All-Terrain Vehicle Statutes . Submitted to the 114th Maine Legislature, First Regular Session, Augusta, ME.

This report presents the results of an evaluation of “public comments and concerns” (p. 1) related to the efficacy of the Maine statutes of 1985 pertaining to ATV use. Although a

number of environmental, safety, law enforcement and landowner conflicts had arisen, it was perceived that these impacts were manageable and that improved educational resources would further mitigate any unwanted impacts. Specific types of impacts were not detailed in this report; rather, the report offers recommendations about managing ATV use and impacts, based on the public input.

Mason, P. and E. Anderson. 1991. Mount Blue ATV Trail Impact Study. Report to the Maine Department of Conservation Bureau of Parks and Recreation. Unity, ME: Unity College.

The authors present results of a three-year study to assess the impacts of ATV use on Maine's Mt. Blue ATV trail. The findings indicate that impacts to the trail itself and to wildlife and neighboring human residents were minimal. Differences in impact levels between the test plots and the controls were not statistically significant. It is important to note, however, that the authors themselves qualified their findings because of extremely low ATV usage levels. The delayed opening of the trail in the first two years (1989 -90) reduced the overall number of people using the trail and allowed the nearby avifauna to nest and raise their young undisturbed by ATVs. The results show that at low levels, ATV use may have acceptable levels of impact.

Massachusetts Department of Environmental Management. 1995. Report on Policy for Off Road Vehicle Use in Massachusetts Forests and Parks. Boston, MA: Massachusetts Executive Office of Environmental Affairs.

This report describes damage to trail surfaces from ORVs (primarily dirtbikes and ATVs), such as mud holes, erosion, and widening, and notes the "disproportionate level of impact caused by ORVs when compared with other recreational activities" (Executive Summary). The report further indicates the dangers inherent in motorized/non-motorized confrontations and the risk of displacing non-motorized users as a result of ORV impacts. A description of the physics of ORVs is included which explains how the shear forces (spinning tires) and compaction forces (gravity effects that create mud holes) combine to degrade trails significantly. It was also found using GIS data layers that, even in the largest Massachusetts State Parks, there are no areas where ORVs cannot be heard.

United States General Accounting Office. 1995. Federal Lands: Information on the Use and Impact of Off Highway Vehicles. Report to the Honorable Bruce F. Vento, House of Representatives. Washington, DC: U.S. General Accounting Office.

Examined BLM and USFS agency compliance with laws establishing OHV policies on federal multiple use lands. Four BLM resource areas and four USFS ranger districts were studied: three in California, two in Utah, and one each in Nevada, Arizona and Idaho. Case study approach examines issues of background, funding and staffing, designation of land for OHV use, OHV monitoring and enforcement, corrective actions, and user and

environmentalist comments. The report focuses on issues related to under-funding and under-staffing of OHV areas as well as a lack of signage and maps that indicate where ORVs can be legally operated. Noise, erosion and devegetation, habitat destruction, and user conflicts were named almost unanimously as ORV impacts associated with these sites.

Air Quality

The few published air quality studies related to ATV uses tend to be limited to research focusing on snowmobile operation. Some internet sources also discuss air quality, though the internet-publicized research is primarily supported by interest groups. In general, there seems to be a noticeable lack of research about levels and effects of ATV emissions.

Bluewater Network. 1999. "Executive Summary: Off-the-Track: America's National Parks under Siege." San Francisco, CA: Earth Island Institute. December.
<http://www.earthisland.org/bw/ORVexecsumm.shtml>

Based on a study of the effects of ORV use in the National Parks, the report of this environmental interest group detailed seven areas of greatest concern about ORV impacts (wildlife, water and air quality, noise, user conflicts, cultural resource damage, safety, soil erosion, and vegetation destruction). Comments about air quality were notable for their detail; the report stated that, "...nineteen percent of ATVs are equipped with two-stroke engines, which release up to 30% of their fuel unburned into the air...118 times as much smog-forming pollutants as modern cars."

Fussell, L.M.S. 1997. "Carbon Monoxide Exposure by Snowmobile Riders." *Park Science* 17(1): 7-10.

Study quantifies CO emissions from snowmobiles under steady-state conditions. Results indicated that the two stroke engines of snowmobiles tend to emit a significantly higher percentage of carbon monoxide and unburned gasses than do automobiles, and the exposure of snowmobile riders to unburned exhaust gasses exceeds nationally accepted levels. Snowmobile riders are potentially being exposed to unhealthy levels of CO.

Soils, Erosion, and Vegetation Impacts

Soil and vegetation impacts are widely discussed in the literature and are perhaps the most obvious impacts to the casual observer. Soil compaction and the shear forces caused by motorized vehicles create mud holes and gullies that alter hydrologic patterns and increase erosion. Compaction and erosion caused by off-road and all-terrain vehicles reduce the quality of recreational trails and require expanded management efforts to develop and maintain safe, usable trails. More studies are needed to quantify the amount and extent of soil loss attributable to ATV use in the Northeast.

Dregne, H.E. 1983. "Soil and Soil Formation in Arid Regions." Pp. 15 -30, in: Environmental Effects of Off-Road Vehicles: Impacts and Management in Arid Regions . Edited by R.H. Webb and H.G. Wilshire. New York, NY: Springer -Verlag.

The primary effects of ORVs (dirtbikes and four -wheel drive jeeps) on soils are surface disruption, which in creases wind and water erosion, and compaction, which increases runoff. Revegetation is inhibited by lower soil moisture and higher soil density.

Kay, J. 1981. "Evaluating Environmental Impacts of Off -Road Vehicles." *Journal of Geography* 80(1): 10-18.

The results of a study in Salt Lake County, Utah, of soil and vegetation impacts of ORVs show lower species diversity, gullyng, compaction, and increased soil exposure in areas used by ORVs as compared to the control (non-ORV use) area.

Leung, Y-F. 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.

Discusses environmental factors affecting trail degradation. Does not specifically mention ATVs, however, information provided about combinations of climate and geology, vegetation, and topography in relation to trail degradation would be useful in reducing erosional impacts from ATVs and other users.

Payne, G.F., J.W. Foster, and W.C. Leininger. 1983. "Vehicle Impacts on Northern Great Plains Range Vegetation." *Journal of Range Management* 36: 327-331.

Damage to previously undamaged range by a four -wheel drive truck increased with the number of passes over the same area. In the second year of study, aerial photographs showed damage carry-over in the most heavily used sites.

Weaver, T., and D. Dale. 1978. "Trampling Effects of Hikers, Motorcycles, and Horses in Meadows and Forests." *Journal of Applied Ecology* 15(2): 451-457.

Experimental trampling by hikers, horses and motorcycles was used to determine relative impacts. Results show that horses and motorcycles were more damaging than hikers. Motorcycles caused more damage when ascending steep slopes and horses and hikers caused more damage on descent. It should be noted that the authors believe that a motorcycle ridden at speeds in excess of 20 km/h might be more damaging than impacts produced by horses.

Webb, R.H. 1983. "Compaction of Desert Soils by Off-Road Vehicles." Pp. 51-79, in: Environmental Effects of Off-Road Vehicles: Impacts and Management in Arid Regions . Edited by R.H. Webb and H.G. Wilshire. New York, NY: Springer-Verlag.

Webb used a dirtbike to assess soil conditions after repeated passes over a test plot. One, ten, 100, and 200 passes were run to determine the impacts of each level of use. Results indicate that compaction usually occurs just below the surface and can extend up to one meter deep. Repeat passes revealed that compaction increased and infiltration decreased with the number of passes. Tire tracks were visible after just one pass, while most annual vegetation was removed after ten. Berms formed at the sides of the 100- and 200-pass trail and the center of the trail surface was indented.

Webb, R.H., et al. 1978. "Environmental Effects of Soil Property Changes with Off-Road Vehicle Use." *Environmental Management* 2: 219-233.

Results of the study of six soil types in Central California show that vehicle traffic increases erosion, impedes revegetation, and decreases soil nutrients. Although clay soils had no decrease in soil moisture, they experienced increased surface strength. Sandy and loamy soils had decreased surface strength and lower soil moisture.

Wilshire, H.G., et al. 1978. "Impacts of Vehicles on Natural Terrain at Seven Sites in the San Francisco Bay Area." *Environmental Geology* 2: 295-319.

Effects of two and four wheel vehicles on study sites included increased surface strength and density, which caused increased runoff and decreased water infiltration, reduction of soil moisture and reductions in organic carbon. These impacts prevented revegetation, and the increased sediment yield and runoff were found to affect adjacent sites.

Impacts on Wildlife

Wildlife impacts have been most studied in relation to Western habitats and in regards to snowmobile use. Wildlife are negatively impacted by the presence and noise of ATVs, ORVs, and snowmobiles, although some mammals (deer, for example) sometimes become habituated to these vehicles over time. Snow compaction also affects the survival and nesting habits of small mammals. Significant ATV-related, Eastern studies have not been completed.

Dorrance, M.J. 1975. "Effects of Snowmobiles on White-Tailed Deer." *Journal of Wildlife Management* 39: 563-569.

The study examined the effect of snowmobiles on home range size, daily activity, and movement of white-tailed deer in St. Croix State Park and Mille Lacs Wildlife Management Area in Minnesota. The two -year study showed a negative correlation between the number of deer along trails and the number of snowmobiles registered at the trailhead. Deer did return to the vicinity of the trails after periods of heavy use but their home ranges increased. Response increased with higher exposure, but there was evidence of habituation to snowmobiles in high use areas.

Hall, C. and P. Dearden. 1984. The Impact of "Non-Consumptive" Recreation on Wildlife: An Annotated Bibliography. Monticello, IL: Vance Bibliographies.

Growth in participation in non-consumptive outdoor recreational activities such as hiking, backpacking, photography, skiing, snowmobiling, and other uses that do not involve the actual consumption and depletion of the resource (such as ATV use), is discussed. This introductory text describes the impacts of land-based non-consumptive activities on wildlife populations and habitats, and provides an annotated bibliography. Most of the literature cited relates to general recreational impacts, although several entries specifically address ORV impacts. These include:

Primack, M. 1980. "O.R.V.s in Our National Seashores." *National Parks and Conservation Magazine* 54(11): 4-7.

The large numbers of ORVs used in coastal ecosystems are partly responsible for the scale of the impact. Beach-dependent wildlife such as turtles can become disoriented by tire tracks and the compacted sand makes it difficult for them to nest.

Sheridan, D. 1978. "Dirt Motorbikes and Dune Buggies Threaten Deserts." *Smithsonian* 9(5): 65-75.

Sheridan cites recent studies that have shown a 50-90% decrease in plant life and a 60-75% decrease in animal life in areas of the California desert that are heavily used by ORVs.

Stace-Smith, R. 1975. "The Misuse of Snowmobiles Against Wildlife in Canada." *Nature Canada* 4(4): 3-10.

The author describes incidents of snowmobilers chasing down and injuring wildlife. Further wildlife impacts include compaction of the insulating snow layer which reduces the numbers of small mammals.

Wanek, W.J. 1971. "Observations on Snowmobile Impact." *Minnesota Volunteer*, November-December: pp. 1-9.

The article describes the reaction of deer to snowmobile use. Deer appear to become acclimated to snowmobiles in areas of heavy use, but they react markedly to the machines in areas where snowmobiles seldom go.

Joslin, G., and H. Youmans, coordinators. 1999. Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. Committee of Recreation on Wildlife, Montana Chapter of the Wildlife Society. 307pp.

This review describes the effects of recreation and human disturbance on a wide range of wildlife. Populations and diversity of small mammals were found to be inversely related to the level of ORV use in an area (p. 4.10). It was postulated that ORV use could alter the drainage patterns of bog environments with a negative impact on hydrologic functions. Snowmobiles were implicated in reducing the insulating characteristics of the snow layer, which provides protection to small mammals and insulates the soil from excessive freezing.

Vieira, M.E.P. 2000. Effects of Early Season Hunter Density and Human Disturbance on Elk Movement in the White River Area, Colorado. Unpublished M.S. Thesis. Fort Collins, CO: Colorado State University.

Vieira studied the effects of both pedestrian and ATV (four wheeler) effects on movement patterns of elk in the White River, Colorado, area. The mean distance moved by the elk in response to the ATV was more than twice the pedestrian mean. Using radio collared elk and an airplane, Vieira was able to measure the distance traveled by each elk in response to various disturbances. The study was in response to concerns about elk moving from National Forest land onto private land, and considered whether increased ATV use by hunters could be responsible for greater flight distances and greater chances of elk entering private land.

Forest-Related Research and Impacts

ATV use has been found to widen and rut roads, further fragmenting forest habitat, to create noise conflicts with other users that reduce their recreational enjoyment, and to increase the sediment load to streams which may threaten fisheries.

Adams, J.C. 1998. Treadmarks on the Virgin Land: The Appropriate Role of Off -Road Vehicles in National Forests. Unpublished M.S. Thesis. Missoula, MT: University of Montana.

The author discusses the importance of a natural experience to recreationists, and argues that ORVs preclude a natural experience for both the riders and for non -motorized users. ORVs are considered an intrusion into primitive and semi -primitive areas, eliminating the possibility of having a unique experience in nature. The author writes, "Trails are for people, roads are for vehicles" (p. 139). Adams pursues the argument that beyond their environmental impacts, ORV use is detrimental to the landscape because it destroys the ability for other users to obtain a peaceful communion with nature.

Da Luz, S., Jr. 1999. Off Road Vehicle Impacts on Soil Properties of Trails in Wayne National Forest, Southeastern Ohio. Unpublished M.S. Thesis. Columbus, OH: Ohio University.

Results of the study indicate that the rate of soil generation in the forest did not compensate for the amount of sediment lost due to ORV use on trails in Wayne National Forest. In addition to quantifiable erosion acceleration, it was found that off-season soil rebound did not reverse the compaction effects of the previous season's ORV use. This study is significant because it demonstrates the erosion and compaction effects of ORV use in the more humid, eastern region of the United States.

Dennis, D.F. 1998. "Analyzing Public Inputs to Multiple Objective Decisions on National Forests Using Conjoint Analysis." *Forest Science* 44(3): 421-429.

D. Dennis used a conjoint analysis technique to interpret a sample of 76 respondents' views on the management of the Manchester Ranger District of the Green Mountain National Forest, VT. Respondents were presented with a choice of 18 alternative management combinations with varying levels of timber harvest, wildlife, hiking opportunities, snowmobiles, and ORV use. Statistical analysis of survey results showed that preferences were for maintenance of the existing level of snowmobile use and the prohibition of use of 3- and 4-wheel ORVs and motorized trail bikes in the forest.

Dennis, S.R. 1987. "Off Road Vehicle Policy and Arizona National Forests." Pp. 197 -212, in: Social Science in Natural Resource Management Systems. Edited by M.L. Miller, R.P. Gale, and P.J. Brown. Boulder, CO: Westview Press.

The author describes the benefits of ORV recreation as providing pleasure to a large segment of the population by providing access to remote terrain, contact with nature and a means to build family ties. However, the costs of this type of recreation are soil, wildlife, and vegetation impacts and conflicts with non-motorized users. S. Dennis notes that user habits and intensity of use play a role in the extent and nature of impacts.

Major, M.J. 1987. "Managing Off-Road Vehicles." *Journal of Forestry* 85(11): 37-41.

This article explains that despite the efforts of user groups and public agencies to mitigate negative ATV impacts, the sheer number of users and the constantly changing ATV profile (dirtbikes to four wheel drives to ATVs) makes many impacts difficult to mitigate. Trail widening and rutting as well as noise pollution that conflicts with non-motorized users were cited as areas for concern. Wayne-Hoosier State Forest in Indiana, which has been closed since 1971 due to the social impacts that ORV noise and operation cause, was cited in the article. An important impact mitigation tool is the support of and cooperation with user groups. Many ATV clubs sponsor trail maintenance and educate their members in lower impact riding.

Wilkinson, T. 1999. "The Forest Service Sets Off into Uncharted Territory." *High Country News* 31(21): 8-13.

Wilkinson's article describes the conflict between the Forest Service and off-road vehicle users over the fate of thousands of miles of forest roads. The roads fragment wildlife habitat and provide sediment that threatens fisheries and clogs streams. However, they also provide easy access for thousands of Americans who believe that they have a right to recreate as they please on public land. In 1999, President Clinton requested an environmental impact study from the Forest Service that was to include a decision on how to deal with roadless areas.

Woods, L.E. 1981. "ORVs on the National Forests: A Classic Case of Listening." *American Forests* 87(11): 40-43, 58-61.

The author explains that people are attracted to ORVs for a variety of reasons, including using the vehicles to spend time with one's family, to challenge oneself, and to get out into nature. There is a discussion of cooperation between environmental and ORV groups in Washington State in the siting and design of a proposed ORV trail.

Recreation Impacts: Participants and Experiences

One of the most contentious impacts of ATVs is their conflict with non-motorized users including hikers and cross-country skiers. The noise and intrusion of the modern world into nature (particularly in distant or secluded areas) compromises the enjoyment of many user groups. ATVs, ORVs, and snowmobiles, however, do offer opportunities for people to access more challenging terrain and remote resource places. The increasing numbers of visitors using motorized vehicles for recreation, though, creates significant environmental degradation and social conflict with other recreationists.

Badaracco, R.J. 1976. "ORVs: Often Rough on Visitors." *Parks and Recreation* 11(9): 32-35, 68-75.

The first part of the article is a review of the literature that includes discussion of the one-way nature of user conflicts (ORV versus non-ORV), and spatial conflicts that occur as a result of non-ORV's need for space for solitude and ORV's need for space for a challenge and adventure. The second part of the article includes a description of the ISD (impairment, suppression, displacement) syndrome. Impairment refers to the decreased enjoyment of non-ORV's because of ORV impacts; suppression refers to reduced participation of the affected group; displacement refers to the final abandonment of a site as a result of sustained impact. Managers often mistakenly interpret displacement as a decrease in demand for the abandoned activity and often commit greater resources to the offending activities.

Cole, D.N. 1986. "Resource Impacts Caused by Recreation." Pp. Management 1-12, in: A Literature Review. The President's Commission on Americans Outdoors. Washington, D.C.: US Government Printing Office.

The review describes recreational impacts including trampling and erosion and places particular stress on areas where research is lacking such as wildlife and recreational impacts and monitoring systems. ORV impacts are given particular attention, as their riders desire challenging terrain that is often most at risk for degradation. ORVs were implicated as the worst offenders among recreation types because they have the ability to cause erosion and vegetation impacts over large areas.

Crimmins, T. 1999. Colorado Off-Highway Vehicle User Survey: Summary of Results. Colorado State Parks OHV Program.
www.outdoorlink.com/amtrails/resources/motors/motCoOHVsurvey/html

A survey of 784 Colorado OHV users showed that most respondents traveled an average of 29 miles while using their OHVs for recreation. Indications are that most riders would like trail systems of *at least* 29 miles in order to provide a variety of scenery and terrain

types and to eliminate the temptation to create new routes. Survey results also revealed that almost 80% of respondents rode in groups of four or less. Respondents supported new funding for: 1) right-of-way purchases, 2) new trail construction, and 3) erosion control. Some respondents commented that reckless use or use during inappropriate times could lead to environmental impacts, while others felt that the impacts of wheeled vehicle travel may be no more than impacts from other uses. Though the survey was targeted to off-highway motorcycle and ATV owners, results showed that these respondents owned a total of 3,534 motorized vehicles (888 off-highway motorcycles; 1194 ATVs; 164 dual sport motorcycles; 363 snowmobile; 694 four-wheel drive vehicles; and 231 sport utility vehicles). Respondents had the following characteristics: 97% were male; 99.97% were Caucasian; their average age was 48; and 62% had some schooling beyond high school.

Jackson, E.L. and R.A.G. Wong. 1982. "Perceived Conflict Between Urban Cross-Country Skiers and Snowmobilers in Alberta." *Journal of Leisure Research* 14(1): 47-62.

The authors studied perceived conflicts between two types of recreationists – snowmobilers and cross-country skiers – using provincial public lands in Alberta, Canada. The authors note (p. 59) that, "cross-country skiers are sensitive to and affected by the presence of snowmobilers, while the reverse is not the case." This asymmetrical conflict may be due to the need for solitude, quiet, and undisturbed natural areas that characterizes cross-country skiing.

Kockelman, W.J. 1983. "Management Concepts." Pp. 399 -446, in: Environmental Effects of Off-Road Vehicles: Impacts and Management in Arid Regions . Edited by R.H. Webb and H.G. Wilshire. New York, NY: Springer -Verlag.

Noise and motorized intrusion were cited as the major negative impacts of ORVs by other non-motorized users. ORV use is considered "inefficient" to the multiple -use concept because a single machine, through noise, dust and speed, can exclude all other recreationists from an area that could otherwise have been enjoyed by many. The author describes three general categories of ORV users: work-related users, recreational users, and "bad apples." Work-related users include natural resource managers and utility workers, among others. Recreationists are divided into casual and endurance riders. Casual users value aesthetics over the challenge desired by endurance riders. The "bad apples" are characterized by blatant disregard for impacts and actions and lack of respect for laws and consequences.

Knopp, T.B. and J.D. Tyger. 1973. "A Study of Conflict in Recreational Land Use: Snowmobiling vs. Ski Touring." *Journal of Leisure Research* 5(3): 6-17.

The authors used a survey to assess skier and snowmobiler attitudes towards public land use and to each other. The results indicate that while motorized recreation severely impaired the natural experience of the skiers, the skiers had little effect on snowmobilers. Though the focus of this article is primarily on snowmobiles, it illustrates the kinds of recreational conflicts that emerge when motorized and non-motorized recreationists meet (and which are typically discussed in the research literature about ATV, OHV, and snowmobile studies).

Lindsay, J.J. and C.P. Cialdi. 1978. Vermont Trail Bike Study. University of Vermont, School of Natural Resources, Recreation Management Program, Research Report SNR-RM5.

The report includes background and recommendations for reducing conflict between riders and other individuals. The author s recommend that trails be developed on private land to reduce user conflicts, that they be sited on impact-resistant surfaces with good sound buffers, and that they be about 23 miles in length and take about three and a half hours to complete.

Malone, R. 1981. "ORVs: Kicking Up Dust." *American Forests* 87(11): 43, 61-63.

This article discusses the popularity of ORV use, the contrast between "renegade" and conscientious ORV users, and the conflict between motorized and non-motorized recreation.

Nichols, G.E. 1979. "Responsible Off-Road/Off-Highway Vehicle User Impact on Wildlands." Pp. 199-202, in: *Recreational Impact on Wildlands*. Conference Proceedings. Seattle, WA: U.S. Forest Service Region 6, R-6-001.

The author describes five types of use: learning experience, play activity, structured competition, play experience, and recreational trail experience. Learning experience is the stage in which riders learn how to handle their machines. Play activity, structured competition, and play experience are associated with the increased challenge of handling the vehicle in difficult terrain and conquering nature. The final type of activity, recreational trail experience, places more emphasis on fellowship, aesthetics, and identification with nature.

Noe, F.P., J.D. Wellman, and G. Buhyoff. 1982. "Perception of Conflict Between Off-Road Vehicle and Non Off-Road Vehicle Users in a Leisure Setting." *Journal of Environmental Systems* 11: 223-233.

The authors used a goal-interference model at Cape Hatteras National Seashore to evaluate ORV/non-ORV conflicts. Results show a one-way conflict such that ORVs affect the recreational experience of non-ORVers, but not vice-versa. Fundamental differences in opinion over such issues as desired level of control over recreation and who is to blame for adverse impacts exist between the two groups. Non-motorized users think more control of all recreationists should be considered to preserve the resource, while ORVers disagree.

Snowmobiles

Snowmobiles have been shown to cause impacts of their own, despite popular opinion that absolves them of guilt because of their operation on snow. Studies show that compaction of the insulating snow layer compromises the habitat of mammals living below the snow layer, and may put undue stress on large ungulates such as moose and deer. Furthermore, snowmobiles share the same noise characteristics as their ATV counterparts. Since snowmobiles are not included in the Vermont State Statutes regarding ATVs, we have not annotated the following sources, but add them here simply as further reference materials.

U.S. Department of the Interior. 2000. Air Quality Concerns Related to Snowmobile Use in National Parks. Denver, CO. National Park Service Air Resources Division.

Foresman, C.L., et. al. 1973. Effect of Snowmobile Traffic on Non-Forest Vegetation. Madison, WI: School of Natural Resources, College of Agricultural and Life Sciences, University of Wisconsin-Madison.

Richens, V.B. and G.R. Lavigne. 1978. "Response of White -Tailed Deer to Snowmobiles and Snowmobile Trails in Maine." *Canadian Field Naturalist* 92: 334-344.

Borrie, W.T., et al. 1999. Winter Visit and Visitor Characteristics of Yellowstone National Park . Final Report. Missoula, MT: School of Forestry.

Greer, T. 1979. Environmental Impact of Snowmobiles: A Review of the Literature . Master's Project, Eugene, OR: Department of Recreation and Park Management, University of Oregon.

Bibliographies

The following sources provide extensive reference bibliographies about off-road vehicles and their impacts, and some citations in these sources are annotated. Because many of the citations in these bibliographies are not contemporary but derive primarily from the 1970s and 1980s, and since many are focused on arid landscapes of the Southwest rather than on northern forested and mountain areas, we have not re-annotated the individual citations. Instead, a full copy of the texts of the Williams and Lester (1996) and Albrecht and Knopp (1985) bibliographies are included in Appendix A in this report. (The Garland bibliography is available locally.)

Williams, M. and A. Lester. 1996. "Annotated Bibliography of OHV and Other Recreational Impacts to Wildlife." U.S.D.A. Forest Service Pacific Southwest Region.

Albrecht, J. and T. Knopp. 1985. "Off Road Vehicles – Environmental Impact – Management Response: A Bibliography." St Paul, MN: University of Minnesota Agricultural Experiment Station Miscellaneous Publication.

Garland, L. E. 1998. Annotated Bibliography of Wildlife Responses to Selected Human Land Use and Recreational Activities. Waterbury, VT: Vermont Fish and Wildlife Department.

Miscellaneous

The following sources do not contain specific or detailed research findings about ATV and ORV impacts, but are added here as evidence of broad scholarly and public interest in these and related topics.

Harrison, R.T. 1979. "Predicting Off-Road Vehicle Acoustic Impact on Forest Recreation – A Simplified Method." In: *Recreational Impact on Wildlands*, Seattle, Conference Proceedings, pp. 120-137. U.S. Forest Service Region 6, R-6-001.

Nicholes, G.E. 1980. "Off-Road Vehicle Trends." Pp. 127-134, in: Proceedings: 1980 National Outdoor Recreation Trends Symposium. Volume 1. Broomall, PA: USDA Forest Service, Northeastern Forest Experiment Station. General Technical Report NE -57.

Slaughter, C.W. and C.H. Racine. 1990. "Use of Off-Road Vehicles and Mitigation of Effects in Alaska Permafrost Environments: A Review." *Environmental Management* 14(1): 63-72.

Turner, D.S. 1991. "Are Desert Visitors Turning Fragile Soils into Dust?" *High Country News* 23(21): 12.

Williams, F. 1991. "A Passive Town in Utah Awaits its Fate." *High Country News* 23(21): 1, 8-9, 11.

Wilson, J.P. and J.P. Seney. 1994. "Erosional Impact of Hikers, Horses, Motorcycles, and Off-Road Bicycles on Mountain Trails in Montana." *Mountain Research and Development* 14(1): 77-88.

Addendum

We were unable to obtain the following report, though it has been referenced in a variety of other sources and may be of interest to readers:

Chilman, K.C., and J.J. Vogel, et. al. 1991. Turkey Bay off-road vehicle area at Land Between the Lakes: Monitoring use and impacts since 1973.

Internet Sources

Safety Issues

<http://www.aaos.org/wordhtml/papers/position/atvs.htm>

American Academy of Orthopedic Surgeons position statement on the public safety risks of ATVs.

http://www.nsc.org/mem/youth/6_atvfs.htm

National Safety Council ATV safety, along with general ATV facts and operating recommendations.

Industry Sources

<http://www.truckworld.com/NewProducts/1hpATV.html>

Truckworld's new ATV product reviews.

http://www.mic.org/_index.html

Motorcycle Industry Council homepage. Riding and industry information, some of which is password-protected. "To promote and preserve motorcycling and the motorcycle industry."

See also the home pages of: Honda, Yamaha, SkiDoo, and other industry sources

Interest Organizations

<http://www.vtvast.org/>

Vermont Association of Snow Travelers, a 33,000+ member group that organizes and maintains Vermont's 5,000 miles of snowmobile trails.

<http://sharetrails.org/>

Blue Ribbon coalition homepage. Links to industry and advocacy information. BRC works for increased access for motorized recreation and for increased sharing of resources

<http://www.nonoise.org/news/snow.htm>

Noise Pollution Clearinghouse compilation of ATV noise -related articles from around the country.

<http://www.sierraclub.org>

Sierra Club homepage with searchable links to articles and action reports on ORVs.

<http://www.sierraclub.org/policy/conservation/offroad.asp>
Sierra Club off road vehicle policy

<http://www.sierraclub.org/chapters/id/orv/#fact>
A citizen handbook for off-road motor vehicle regulation; Sierra Club

<http://www.suwa.org/newsletters/1999/winter/21.html>
Southern Utah Wilderness Association Newsletter. "SUWA Launches Campaign to Curtail Off-road Vehicles"

<http://www.wildlandscpr.org/>
Wildlands Center for Preventing Roads. Links to ORV information including a report on ORV use in the National Forests.

http://www.wilderness.org/standbylands/orv/skidmarks_051600.htm
The Wilderness Society ORV page with links to related articles.

<http://www.wilderness.org/index.shtml>
Wilderness Society homepage with searchable database of articles and position statements regarding ORVs.

Public Lands

<http://www.wildwilderness.org/wi/eo11989.htm>
Executive Order 11989 regarding ATV use on public lands.

<http://www.nps.gov/>
National Park Service website has searchable database with some ATV and ORV links.

<http://www.fs.fed.us/>
United States Department of Agriculture, Forest Service, website has searchable database with many links to ORV/ATV -related information, much of which is specific to individual forest areas.

<http://www.blm.gov/nhp/index.htm>
Bureau of Land Management page with news releases and FOIA links.

News and Public Commentary

<http://www.nap.edu/issues/16.1/anderson.htm>
Article by H. Michael Anderson in *Issues in Science and Technology*, "Reshaping National Forest Policy." Includes a brief mention of ATV policy in National Forests.

http://seattletimes.nwsourc.com/news/local/html98/allt_19991212.html

“All Terrain Vehicles Now Leisure Favorites,” in *The Seattle Times*. Discusses popularity and draw of ATVs.

<http://detnews.com/1999/nation/9912/08/12090002.htm>

“Environmentalists Want to Restrict Off -Road Vehicles” *Detroit News Online*
Commentary on the debate over whether or not to ban ORVs in National Forests and Parks.

<http://seattlep-i.nwsourc.com/local/dark07.shtml>

“Boots and Wheels Fight Over the Trails” *Seattle Post-Intelligence*. Commentary on the conflict between hikers and dirtbike riders.

<http://www.news-journalonline.com/2000/Aug/11/FLA16.htm>

Article titled: "Off-road vehicles to be restricted at Big Cypress"

<http://www.americanlands.org/Forestweb/offroad.htm>

Article titled: "Off-Road Vehicles on Public Lands: A Growing Problem".

<http://www.csmonitor.com/durable/1999/10/05/p3s1.htm>

Article in *The Christian Science Monitor*, “Crush of off-road vehicles plies West's public lands.”

Future Research Needs

The review of literature reveals inconsistencies in use of terminology for motorized, off-road vehicles, and lack of standards in assessing levels of impacts. Some vehicle types have received increasing attention from researchers (for example, snowmobiles and motorcycles), while others have been studied primarily in more general terms (3- and 4-wheel vehicles of all types, as well as jeeps and trucks used for off-highway driving). Additionally, it is difficult to measure impacts when many types of users – humans with animals (horses and llamas), mountain bikes, motorcycles, 3- and 4-wheel vehicles, trucks, and other 2- and 4-stroke engine vehicles – all use the same resource areas, sometimes simultaneously. Research based on experimental designs or observational techniques to study activity types and impacts has generally failed to account for the complexity of interactions among uses, users, and impacts. Moreover, research about ATVs, ORVs, and OHVs and their impacts has been quite limited in settings involving temperate climates, forested and mountainous regions, and landscapes with mixed use areas and land ownership patterns, such as the Northeast region of the U.S.

Contemporary research is needed in addressing all categories of impacts discussed in this report, but special attention should be given to regional studies that consider particular qualities of the geography, climate, human uses, and land ownership patterns of Vermont and the Northeast. Comparative research evaluating the impacts of different types of motorized vehicles and different types of landscape qualities should be conducted. Specific indicators are needed to assess levels of changes in impact categories associated with vehicle type and levels of use. Both quantitative as well as qualitative indicators are needed, especially for understanding conflicts arising from

encounters between non-motorized recreational users and motorized users, and for evaluating reduced quality in recreation experiences.

The review of research literature outlined in this report suggests that future research might begin to address evident information gaps with studies on the following topics:

1. Baseline research about ATV/ORV users and uses, including survey research about the socio-economic characteristics of users; locations and patterns of use; desired experiences; user values for environments and experiences; attitudes toward management activities; changes and trends in use and distribution of motorized uses over time and human life span; and other demographic and activity participation issues, including differences within various locales and states in the Northeast region.

2. Research about human communities, including on-site research focused on attitudes and behaviors of diverse types of recreationists competing for use of specific resource areas; impacts of motorized users on non-motorized users, and vice versa, and the ways in which different magnitudes of impacts are viewed by different kinds of users; off-site research in local communities (rural as well as urban) to document non-recreational, work-related uses of ATVs and ORVs; off-site research about social issues related to ATVs and ORVs (the range and overlap of social networks of motorized users; rhetorical strategies in presenting group messages and maintaining user group boundaries; group norms associated with safe driving activities; effects of educational campaigns across motorized user groups; and other social issues).

3. Research related to management activities on both public and private lands for ATV and ORV use, including assessment of current management policies and practices, basic allocation decisions, existing relationships between public and private property owners, interest group participation in management activities, and planning and design concerns. Future research should also include analysis of needs for: new construction (trails, roads) and facilities, enhanced budgets and operating expenses, increased personnel for control and enforcement, needs to improve educational efforts, assessment of acceptable impacts levels, and analysis of outcomes associated with implementation efforts.

4. Environmental impacts research, in which ATV and ORV uses are specifically studied in Vermont and other Northeast landscapes to assess their impacts on natural environments. Topics should include ATV effects on forest fragmentation, trail rutting and erosion, wildlife impacts and habituation, air quality, noise effects across landscapes (valleys vs. mountainous terrain), and others. GIS mapping should be included as a tool for analyzing changes across terrestrial resource systems and effects of changes in use across watersheds, and data should be collected so as to assess time and location variability.

APPENDIX A

Further research to evaluate the utility of large environmental databases in the analysis of selected scientific and regulatory questions therefore would be timely. The primary purpose of this paper is to provide an annotated review of selected literature on the topic of information integration in the context of environmental monitoring and assessment. Based on a review of this literature, significant scholarly contributions to this field have been identified as falling into the following four issue areas: institutional, resource/ecological, design, and technological. The effect of deleting a single large-valued observation on the mean is linear, and on the standard deviation it is nonlinear (approximately quadratic). Annotated Bibliography. Adams, P. (2006). Exploring social constructivism: theories and practicalities. *Education*, 34(3), 3-13. The research the authors perform is with pre-service teachers which relates to my topic. In this article Charoula Angeli and Nicos Valanides explore the issues surrounding the changing field of pre-service teacher education and the relevance of technology integration in the content areas. This may provide insight into the effect of emerging technologies on the constructivist learning theories and pedagogies. Balioan, N., Hoeksema, K., Hoppe, U., & Milrad, M. (2006). Bandura's paper explains the impact of social influences through modeling, instruction and social persuasion.