Aldo Leopold Wilderness Research Institute: Publication # 180
CITATION: Cole, David N. 1989. Recreation ecology: what we know, what geographers can contribute. Professional Geographer. 41(2): 143-148.

RECREATION ECOLOGY: WHAT WE KNOW, WHAT GEOGRAPHERS CAN CONTRIBUTE*

David N. Cole
USDA Forest Service

Geographers have made substantial contributions to the field of recreation ecology, the study of recreational impacts on the environment, despite the absence of a uniquely geographic perspective. Knowledge about recreation impact is still rudimentary and open to further contributions by geographers. Three areas where geographic methods seem particularly useful are (1) understanding the spatial variability of site susceptibility, (2) analyzing spatial distributions of impact, and (3) integrating social and ecological concerns in the development of management programs.
Key Words: recreation impact, site susceptibility, spatial distribution, recreation ecology.

Cries for action have grown less shrill since the early 1970s, but concern for the effects of human activities on the environment still commands considerable public attention. One research thrust within human impact analysis studies the impact of recreation on natural and semi-natural environments, a field termed *recreation ecology* by British researchers in the early 1970s (Cole 1987).

Participation in outdoor recreation activities, such as hiking, camping, skiing and boating, has increased greatly in recent decades. These pursuits are highly valued by a substantial proportion of the population, and they depend on a largely natural environment. Disturbance of natural environments has increased along with recreational use, resulting in increases in maintenance costs, declines in the quality of recreation experiences, and compromises of preservation objectives. In wilderness, recreation impacts also compromise nonrecreation values, such as ecological, scientific, and scenic values. Recreation ecology research has responded to this problem.

Most research on recreation impact has been conducted within the disciplines of forestry, resource management, and the biological sciences. A search of the literature indicates that geographers have contributed about 15% of the published work in the field. Of 22 geographers or groups of geographers with published works, nine were from universities and research institutions in the United States. Geographers from Great Britain, Canada, Norway, South Africa, Hong Kong, and Australia also have published in the field. I located five geography doctoral dissertations. Masters theses and papers presented at meetings of the Association of American Geographers are considerably more numerous.

Contributions by geographers are highly varied. Geographers frequently use tools from botany, soil science, and forestry to investigate how recreational activities alter the environment. Other contributions integrate both the ecological and social concerns inherent to recreation management. Although such perspectives are not uniquely geographic, geographers are often particularly skilled in such research due to the breadth of their training. Other contributions depend on spatial analysis.

In this paper I review the status of recreation impact analysis, suggest places where further contributions would be particularly welcome, and describe the types of research most likely to profit from a geographic perspective. My goal is to inspire more geographers to focus their skills on solving the undesirable impact problems that accompany recreation use.

* I am grateful for the helpful comments of Katherine Hansen-Bristow on an early draft of this paper.

What We Know About Recreation Ecology

Most recreation impact research consists of largely descriptive case studies of the effects of specific activities (for example, trampling or driving off-road vehicles) or of the impacts found at specific locations, particularly on campsites or trails. Such studies require basic skills in the analysis of vegetation, soils, animals, and water. Many geographers possess these skills and have contributed to our understanding of the changes that accompany recreation use.

Effects of trampling on vegetation and soil have been studied most frequently (Liddle 1975; Wall and Wright 1977; Cole 1987; Hammitt and Cole 1987). Trampling can reduce plant height, vigor, reproductive capacity, and abundance. Where recreation use is heavy, all ground cover vegetation, except that in protected places, may be eliminated. Variations in the tolerance of different species for trampling result in changes in species composition on recreation sites. Tree seedlings are particularly fragile and are eliminated quickly on campsites. In the Boundary Waters Canoe Area of northern Minnesota, for example, campsites have typically lost 85% of their undergrowth vegetation and all tree reproduction (Frissell and Duncan 1965). Trampling usually has little evident impact on overstory trees, but when the overstory eventually dies, there may be no replacement trees.

Trampling also abrades organic horizons and compacts mineral soils. Compaction reduces water infiltration rates, which leads to increased runoff and erosion. On backcountry campsites at Grand Canyon National Park, AZ, soil bulk density was typically 20% higher, and infiltration rates were almost 80% slower than on adjacent undisturbed sites (Cole 1986).

Many of the effects of off-road vehicles (ORVs) are similar to those of trampling, although their capacity to cause impact is much greater than that of humans (Weaver and Dale 1978). Erosion is a particularly severe consequence of ORV use. At an ORV site near San Francisco, CA, the rate of erosion was 30 times greater than the rate that the Bureau of Reclamation considered to be a serious problem (Wilshire et al. 1978). Snowmobiles have less impact than other ORVs because snow, if sufficiently deep, shields the vegetation and soil surface. The major concern about snowmobiles is their influence on wildlife, particularly small mammals, such as voles, that live between the snow and soil (Bury et al. 1976).

Case studies of recreation impact on animals are numerous (Boyle and Samson 1983), but results are often contradictory and highly site- and species-specific. Studying animals' reactions to recreational use is difficult because undisturbed populations are hard to locate and mobile animals are usually difficult to monitor. The impacts of recreationists on wildlife may be most severe in winter when animals are weak and stressed (Moen 1976). The impacts of cross-country skiers are currently a major concern in Yellowstone National Park, WY.

Researchers who examined the physical, chemical, and biological qualities of surface waters in and around recreation areas usually found little alteration of water quality from second home development (Ponce and Gary 1979), swimming (Nelson and Hansen 1984), use of developed campgrounds (Aukerman and Springer 1976), or dispersed recreation use (McDowell 1979). Recreation-caused bacterial contamination was identified, however, in the Indian Peaks Wilderness, CO (Hansen-Bristow et al. 1982); and physical, chemical, and biological changes were found in lakes in Kings Canyon National Park, CA (Taylor and Erman 1979). Use of roads and ORVs can lead to increased sedimentation of streams and detrimental effects on fisheries; however, research is insufficient to evaluate the severity and frequency of problems.

Unfortunately, only the more obvious effects of recreational activities are documented. Little is known about the effects of trampling on plant physiology or soil microbiology. Such knowledge gaps pre-

vent effective rehabilitation of recreation sites.

Research on factors that influence amount of impact is important because manipulation of these influential factors can mitigate impacts. The relationship between amount of use and amount of impact receives the most attention. Impact increases rapidly as use increases from no-use to low-use levels. Above low-use levels, however, further increases in use have less effect on impact. The precise use threshold, above which further increases in use have little effect on amount of impact, varies with type of use, season of use, durability of the environment, and the type of impact under consideration (Cole 1987).

Users vary greatly in their potential to cause impact. Impact potential generally increases from humans to pack stock to motorized vehicles. A controlled experiment on a sloping mountain grassland (*Poa pratensis* and *Festuca idahoensis*) in Montana found that 200 motorcycle passes removed twice as much vegetation as the same number of passes by a horse and nine times as much vegetation as 200 hiker passes (Weaver and Dale 1978). Other user characteristics that are likely to influence impact include party size, length of stay, and knowledge and commitment to minimizing impacts. Impact potential also varies between seasons. When snow is on the ground, impact to vegetation, soil, and water is often low, while impact on wildlife may be high. Spring is often the season of highest vulnerability because in many places the soils are saturated, plants are initiating growth, and animals are recovering from the stresses of winter and from giving birth (Hammitt and Cole 1987). These critical aspects are little studied, however.

Impact is also a function of site durability. The question of how impacts differ across a range of environments is the one most frequently addressed by geographers. Serious trail problems have been linked to certain soil characteristics, vegetation types, landforms, and design features. Footpaths in the English Lake District are widest in heath and most eroded in podsol soils (Coleman 1981). In Rocky Mountain National Park, CO, trails located on alpine colluvial fan and planation surfaces suffer the most severe erosion, while those on bedrock and talus experience the least (Summer 1980). Impacts on camp and picnic sites have been found to vary with such factors as overstory canopy cover and vegetation type (Dykema 1971; Cole 1981). Studies that investigate the spatial variability of impact are particularly valuable because they identify strategies that can reduce impacts without restricting either amount of use or recreational activities.

The importance of understanding the spatial variability of site susceptibility is underscored by the findings of the few studies of change over time on recreation sites. On both developed and wilderness campsites, for example, initial use causes most of the impact (LaPage 1967; Merriam and Smith 1974), while further change on long-established sites is relatively minor (Magill 1970; Cole 1985). Recovery rates on closed recreation sites vary greatly between environments, but are always slower than deterioration rates. Recovery is particularly slow in mountainous areas where growing seasons are short (Willard and Marr 1971) and in deserts where moisture is limited (Webb and Wilshire 1983).

Rapid impact and slow recovery argue for the wisdom of concentrating use and impact on a small portion of a recreation area. A portion of the area is highly altered, but most of the area is spared serious impact. It is critical, however, that those areas on which use is concentrated be either inherently durable or hardened to a more durable state. Otherwise deterioration of the site may reduce the desirability or utility of the site and defeat the use concentration strategy.

Geographic skills are uniquely appropriate to the spatial distribution of recreation impact. The few studies that have been conducted found a pattern of highly concentrated impact. Although heavily used campsites, picnic areas, trails, or sce-

nic overlooks may be highly degraded, neighboring areas are often undisturbed (McEwen and Tocher 1976). In a portion of the Eagle Cap Wilderness, OR, less than 2% of the area had been substantially altered by recreation use (Cole 1981). Concentrated impact reflects the concentrated nature of recreational use (Stankey et al. 1976). Impacts to mobile resources (animals and water) may be more widespread than those to vegetation and soil.

How Geographers Can Contribute

Effective management of recreation resources depends on a better understanding of the impacts of recreationists on those resources. Geographers can utilize interdisciplinary skills to address many important unanswered questions. They might focus on three research areas for which geographic perspectives and methods seem particularly useful: (1) the spatial variability of site susceptibility; (2) the spatial distribution of impacts; and (3) social and ecological concerns in the development of management programs.

The study of spatial patterns of susceptibility requires recognition of inherent landscape variability and analysis of differences between landscape classes. Geographers have used this approach to identify landforms where trails are not highly susceptible to erosion (Summer 1980), plant species indicative of sites where trails should be reinforced (Cole 1983a), and lake and stream locations particularly prone to bacterial contamination (McDowell 1979).

This type of research would help make trail construction and maintenance programs more cost-effective. Trail programs consume a substantial proportion of recreation management budgets, particularly in large parks and wilderness. Much is spent repairing damage due to poor decisions about trail location and design. Site susceptibility studies can identify the capabilities and limitations of different landscape classes, thereby improving location and design decisions.

Understanding the spatial distribution of impact is critical to evaluating the significance of impact problems. Along with consideration of the severity of impact, information about where impact occurs—both the importance of the resources affected and the areal extent of disturbance—is needed to evaluate the seriousness of problems. Mapping skills, with ecosystem characteristics and types and levels of impact as the basic mapping units, are fundamental to this type of research. Cole (1981) used this approach in the Eagle Cap Wilderness, OR, to ascertain that pack stock grazing altered almost three times as much area as the use of trails and campsites. Because ecosystem types disturbed by stock are less abundant than those disturbed by trails and campsites, these findings suggest that stock impacts are particularly significant.

Accurate information about impact locations is also needed for planning and making day-to-day management decisions. Geographers could make substantial contributions to the development of systems for collecting and analyzing such information. Aerial photography has been used to monitor the distribution and spread of ORV impacts (Griggs and Walsh 1981). Although considerable progress has been made in monitoring the condition of trails (Leonard and Whitney 1977), campsites (Cole 1983b), water (American Public Health Association 1975), and recreation use (Roggenbuck and Lucas 1987), more work is needed.

One area of needed work is in developing the potential of geographic information systems (GIS) to aid recreation management. Most land management agencies are purchasing GIS hardware and software, but little consensus exists on what inventory data to collect, how to model linkages between inventory variables, or what types of output are most useful. The potential is obvious; realizing that potential will be a challenge.

To be effective, recreation management depends upon simultaneous consideration of both social and physical-biological goals. Management of recreation impacts is largely management of people's perceptions, behaviors, and needs. Ac-

tions that reduce ecological impacts often restrict recreational opportunities and reduce visitor satisfaction; actions that enhance recreational experiences influence the nature, severity, and distribution of ecological impact. Geographers have made some of the most substantial contributions to integration of both social and physical-biological concerns in management programs. One noteworthy example is implementation of the Limits of Acceptable Change concept (Stankey et al. 1985). In this system, specific objectives are developed for both ecological and social concerns. Monitoring determines whether or not objectives are met, and management strategies are developed for situations where objectives have not been met. Difficulties that typically result when individual problems and places are considered in isolation are minimized with this more integrated approach.

Given society's increased concern about recreation and its impacts on the environment, our knowledge of recreation ecology can only improve. As geographers we can contribute substantially to the progress of recreation ecology by solving some of the important remaining questions.

Literature Cited

American Public Health Association. 1975. *Standard Methods for the Analysis of Water and Wastewater*, 14th ed. New York: American Public Health Association.

Aukerman, R., and W. T. Springer. 1976. Effects of recreation on water quality in wildlands. Fort Collins, CO: US Department of Agriculture, Forest Service, Eisenhower Consortium Bulletin 2.

Boyle, S. A., and F. B. Samson. 1983. Nonconsumptive outdoor recreation: An annotated bibliography of human-wildlife interactions. Fort Collins, CO: US Department of Interior, Fish and Wildlife Service, Special Scientific Report—Wildlife No. 252.

Bury, R. L., R. C. Wendling, and S. F. McCool. 1976. *Off-road Vehicles—a Research Summary, 1969–1975*. College Station, TX: Texas A&M University, Agriculture Experiment Station.

Cole, D. N. 1981. Vegetational changes associated with recreational use and fire suppression in the Eagle Cap Wilderness, Oregon: Some management implications. *Biological Conservation* 20:247–70.

Cole, D. N. 1983a. Assessing and monitoring backcountry trail conditions. Ogden, UT: US Department of Agriculture, Forest Service, Research Paper INT-303.

Cole, D. N. 1983b. Monitoring the condition of wilderness campsites. Ogden, UT: US Department of Agriculture, Forest Service, Research Paper INT-302.

Cole, D. N. 1985. Ecological changes on campsites in the Eagle Cap Wilderness, 1979 to 1984. Ogden, UT: US Department of Agriculture, Forest Service, Research Paper INT-368.

Cole, D. N. 1986. Recreational impacts on backcountry campsites in Grand Canyon National Park, Arizona, USA. *Environmental Management* 10:651–59.

Cole, D. N. 1987. Research on soil and vegetation in wilderness: A state-of-knowledge review. In *Proceedings, National Wilderness Research Conference: Issues, State-of-Knowledge, Future Directions*, comp. R. C. Lucas, 135–77. Ogden, UT: US Department of Agriculture, Forest Service, General Technical Report INT-220.

Coleman, R. A. 1981. Footpath erosion in the English Lake District. *Applied Geography* 1: 121–31.

Dykema, J. A. 1971. Ecological impact of camping upon the southern Sierra Nevada. Ph.D. diss., University of California, Los Angeles.

Frissell, S. S., and D. P. Duncan. 1965. Campsite preference and deterioration in the Quetico-Superior canoe country. *Journal of Forestry* 65: 256–60.

Griggs, G. B., and B. L. Walsh. 1981. The impact, control, and mitigation of off-road vehicle activity in Hungry Valley, California. *Environmental Geology* 3:229–43.

Hammitt, W. E., and D. N. Cole. 1987. *Wildland Recreation: Ecology and Management*. New York: John Wiley & Sons.

Hansen-Bristow, K. J., J. E. Flack, and M. Plam. 1982. Bacterial densities within recreational streams during summer holiday weekends, Indian Peaks study area, Colorado Front Range. *Great Plains-Rocky Mountain Geographical Journal* 10:32–40.

LaPage, W. F. 1967. Some observations on campground trampling and groundcover response. Broomall, PA: US Department of Agriculture, Forest Service, Research Paper NE-68.

Leonard, R. E., and A. M. Whitney. 1977. Trail transect: A method for documenting trail

Agriculture, Forest Service, Research Paper NE-389.

Liddle, M. J. 1975. A selective review of the ecological effects of human trampling on natural ecosystems. *Biological Conservation* 7: 17–36.

Magill, A. W. 1970. Five California campgrounds . . . Conditions improve after five years' recreational use. Berkeley, CA: US Department of Agriculture, Forest Service, Research Paper PSW-62.

McDowell, T. R. 1979. Geographic variations in water quality and recreational use along the upper Wallowa River and selected tributaries. Ph.D. diss., Oregon State University, Corvallis.

McEwen, D., and S. R. Tocher. 1976. Zone management: Key to controlling recreational impact in developed campsites. *Journal of Forestry* 74:90–93.

Merriam, L. C., and C. K. Smith. 1974. Visitor impact on newly developed campsites in the Boundary Waters Canoe Area. *Journal of Forestry* 72:627–30.

Moen, A. N. 1976. Energy conservation by white-tailed deer in the winter. *Ecology* 57: 192–98.

Nelson, D., and W. R. Hansen. 1984. Fecal coliform in the Salt River recreation areas of Arizona. *Journal of Forestry* 82:554–55.

Ponce, S. L., and H. L. Gary. 1979. The effect of lake-based recreation and second home use on surface water quality in the Manitou Experimental Forest. Fort Collins, CO: US Department of Agriculture, Forest Service, Research Paper RM-211.

Roggenbuck, J. W., and R. C. Lucas. 1987. Wilderness use and user characteristics: A state-of-knowledge review. In *Proceedings, National Wilderness Research Conference: Issues, State-of-Knowledge, Future Directions,* comp. R. C. Lucas, 204-45. Ogden, UT: US Department of Agriculture, Forest Service, General Technical Report INT-220.

Stankey, G. H., R. C. Lucas, and D. W. Lime. 1976. Crowding in parks and wilderness. *Design and Environment* 7:38–41.

Stankey, G. H., D. N. Cole, R. C. Lucas, M. E. Petersen, and S. S. Frissell. 1985. The limits of acceptable change (LAC) system for wilderness planning. Ogden, UT: US Department of Agriculture, Forest Service, General Technical Report INT-176.

Summer, R. M. 1980. Impact of horse traffic on trails in Rocky Mountain National Park. *Journal of Soil and Water Conservation* 35:85–87.

Taylor, T. P., and D. C. Erman. 1979. The response of benthic plants to past levels of human use in high mountain lakes in Kings Canyon National Park, California, USA. *Journal of Environmental Management* 9:271–78.

Wall, G., and C. Wright. 1977. *The Environmental Impact of Outdoor Recreation.* Waterloo, Ontario: University of Waterloo, Department of Geography Publication Series 11.

Weaver, T., and D. Dale. 1978. Trampling effects of hikers, motorcycles and horses in meadows and forests. *Journal of Applied Ecology* 15:451–57.

Webb, R. H., and H. G. Wilshire, eds. 1983. *Environmental Effects of Off-road Vehicles: Impacts and Management in Arid Regions.* New York: Springer-Verlag.

Willard, B. E., and J. W. Marr. 1971. Recovery of alpine tundra under protection after damage by human activities in the Rocky Mountains of Colorado. *Biological Conservation* 3: 181–90.

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

DAVID COLE is a research biologist with the Wilderness Management Research Work Unit, Intermountain Research Station, Forest Service, US Department of Agriculture, Missoula, MT 59807. He is interested in biogeography, specifically in research of human impacts on wildland environments.