The Challenge of Scientific Activities in Wilderness

David J. Parsons

Abstract—Science is an appropriate and necessary use of wilderness. The long-term protection of wilderness, including decisions related to the planning and management of wilderness resources, use and values, requires an understanding often available only through scientific investigation. In addition, wilderness provides opportunities for scientific understanding not available in other, less protected areas. Yet the acquisition of scientific information often requires activities that affect wilderness resources and values. Decisions about what scientific activities are appropriate and necessary in wilderness require consideration of apparently conflicting mandates, as well as the balancing of the benefits and impacts of proposed actions. Improved communication and cooperation between wilderness managers and scientists is necessary to assure the best possible science with the minimum possible impact.

The approval and conduct of scientific activities (research, monitoring and inventory) in wilderness present challenges to both managers and scientists. Despite wide recognition of the value of science, concern over the appropriateness and impacts of scientific activities have resulted in the denial of many proposals to work in wilderness. As a result, some scientists perceive wilderness managers as unable (unwilling?) to objectively consider the benefits of a proposed study beyond the narrow needs of the local area. Perceptions of a lack of management interest or understanding of science have led some scientists to avoid working in wilderness. Managers, in turn, become frustrated by a perceived inability (or unwillingness?) of some scientists to understand the philosophical basis of wilderness management and the significance of the impacts their activities may cause. Some scientists consider their research so important that they can't understand why it might not be appropriate or acceptable, even in wilderness. All too often, the result has been the avoidance of wilderness by scientists (Franklin 1987), resulting in less than adequate information and, ultimately, lost opportunities for both science and wilderness.

Concerns about the conduct of science in wilderness most frequently focus on the biophysical, social and aesthetic impacts of scientific activities, including the use of motorized equipment (Parsons and Graber 1991). Examples of the many potential impacts of scientific activities are presented in table 1. These include visual as well as physical and ecological impacts; impacts to individual perceptions of wilderness as well as to ecosystem elements and processes. These are the impacts that frequently lead to denial of research permits, in turn feeding scientists' perceptions that management neither understands nor supports the importance of science.

This paper considers the values of science to wilderness as well as the values of wilderness to science. Relevant legislation and policy as well as scientific understanding of the value of studying wild systems are reviewed. Concerns over the impacts of conducting science in wilderness are also considered. The dilemma of how to balance the scientific values of wilderness with concerns over the impacts of science is discussed, and suggestions are made on how to maximize scientific benefits while assuring the continued integrity of wilderness.

Historical Perspectives on Wilderness Science

Authorizing legislation for most large national parks, the organic acts creating the federal land management agencies and even the 1964 Wilderness Act were largely crafted in a climate that did not recognize the ecological complexity of natural ecosystems or the value of protected areas to regional and global conservation (Christensen 1988). Designation of an area was generally considered adequate to "protect" it from change (Graber 1995). Since little recognition was given to the importance of understanding wild ecosystems, little attention was given to the scientific investigation or monitoring of resource conditions. Scientific benefits accrued largely from limited natural history observations and collections.

In recent years, the context for managing wilderness has changed dramatically. Recognition of the temporal and

Table 1—Representative examples of issues and impacts associated with the conduct of scientific activities in wilderness.

Impact/activity	Example
Live trapping	Wolves, Isle Royale
Radio collars	Bighorn, Grand Tetons
Plot markers	FIA, FS wilderness
Helicopter access	Lake chemistry sampling, FS/NPS
Equipment transport/caches	Death Valley
Fire scar wedges	NPS/FS wildernesses
Wildlife guzzlers	BLM/FWS desert wildernesses
Overflights	Wildlife surveys
Visitor surveys	Beepers, Okefenokee
Prescribed fire	FS wilderness
Mechanical thinning	Grand Canyon, Bandelier
Seismic equipment	Death Valley
Snow and stream gauges	Various
Weather stations	Various

In: McCool, Stephen F.; Cole, David N.; Borrie, William T.; O'Loughlin, Jennifer, comps. 2000. Wilderness science in a time of change conference—Volume 3: Wilderness as a place for scientific inquiry; 1999 May 23–27; Missoula, MT. Proceedings RMRS-P-15-VOL-3. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

David J. Parsons is Director, Aldo Leopold Wilderness Research Institute, USDA Forest Service, Rocky Mountain Research Station, P.O. Box 8089, Missoula, MT 59807 U.S.A., e-mail: djparsons@fs.fed.us

spatial complexity of natural ecosystems and the importance of relatively undisturbed areas to the preservation of biodiversity, together with increased public scrutiny of management decisions, have greatly complicated the role of the wilderness manager. One consequence has been increased pressure to base policy and management decisions on sound science (Christensen and others 1996). However, despite a recognized need for science, "relatively little scientific use has been made of wilderness" (Franklin 1987).

Science and Wilderness

The scientific value of wild areas has long been recognized. Such early conservationists as John Muir and George Perkins Marsh recognized the importance of protected areas to science (Nash 1982). In the 1920s some of the most eminent ecologists of the day called for the setting aside of large natural areas for their scientific value (Adams 1929, Leopold 1921, Sumner 1921). In 1941, Aldo Leopold (1941) stated that "all wilderness areas...have a large value to land science." A year later, E. L. Sumner (1942) wrote "to the men of science, the dwindling wilderness is an irreplaceable reservoir of information on natural conditions." The 1959 Sixth Biennial Wilderness Conference was titled "The Meaning of Wilderness to Science." It offered numerous testimonies to both the value of science to wilderness and of wilderness to science (Brower 1960). Building on a number of earlier reviews of the National Park Service's science program, a 1992 report by the National Academy of Sciences emphasized the importance of science to parks, and, by implication, wilderness, and parks to science (National Research Council 1992). It noted that protecting the resources of parks and wilderness "requires scientific knowledge, and an increasingly sophisticated application of that knowledge. The problems faced...today are too many and too complex to solve without the help of science." More recently, Cole and Landres (1996) provided a thorough review of needed research to support wilderness management.

Although there is a well-documented history of the value of science as an essential tool to informed management of wilderness (Lucas 1986, 1987), the broader values of wilderness to science have not been as widely developed. There is wide recognition of the value of wild areas for teaching about basic ecological processes, serving as reservoirs of biotic diversity and species refugia, and as baselines against which to evaluate the impacts of human activities (Franklin 1981, National Research Council 1992, Sinclair 1998); yet wilderness has not been widely used for such purposes (Franklin 1987). As early as 1959, Cain (1960) recognized the difficulties of expounding on the values of wilderness for scientific research when little significant research had been done there. This continues to be a dilemma for those advocating the need for greater scientific use of wilderness.

The 1964 Wilderness Act (P.L. 88-577) is often interpreted as prohibiting all but the most essential of activities. As in the case of those who view wilderness as areas apart from humans, areas we neither know nor should know much about, the tendency of such thinking is to restrict scientific activities to those absolutely necessary for protection of the immediate area. However, an interesting insight into the thinking of Howard Zahniser, chief architect of the Wilderness Act, about the scientific use of wilderness is found in his comments after a 1959 presentation by Luna Leopold (1960) on the value of wilderness for hydrological research. Zahniser commented about the intended "multiplicity of purposes" for the proposed wilderness system, including "to serve the...scientific...needs of the people" (Leopold 1960). In comments to Leopold, he raised specific concerns about whether areas "established for this multiplicity of purposes" would also be able to adequately serve the scientific needs of the people. He asked "do you think the recreational uses...in these areas would necessarily interfere with the establishment of these bench mark stations and other installations for scientific purposes?" Leopold responded that he thought modest recreational use would be compatible with hydrological research. Zahniser followed up by suggesting the need "to give some distinctive attention to the use of these areas for scientific purposes" and for "some thoughtful program for seeing that these areas are so used." It is clear from this discussion that the chief proponent and architect of the Wilderness Act viewed science, including scientific installations, as an appropriate and desired use of the proposed wilderness system.

Analysis of the legislative history of wilderness strongly supports the value and use of wilderness for science. The 1964 Wilderness Act recognized the value of wilderness to science by stating in Section 4 (b) that "scientific use" is one of the "public purposes" of wilderness. Scientific use was mentioned in equal terms as recreational, scenic, educational, conservation and historical uses. Recognition of the importance of wilderness to science is further supported by statements about the important scientific values of the proposed wilderness system made by Frank Church, acting committee chairman for the Senate Committee on Interior and Insular Affairs, during Committee Explanations (U.S. Congress 1963) and statements made by various sponsors during floor debate on the Wilderness Act (e.g., U.S. Congress 1964). The 1994 California Desert Wilderness Act (P.L. 103-433) is even more explicit in stating that a primary purpose of wilderness is to "retain and enhance opportunities for scientific research in undisturbed ecosystems."

Discussions and hearings leading up to the designation of Hawaii Volcanoes National Park as wilderness in 1978 directly confronted the need for mechanized equipment, mechanical access (helicopters and 4-wheel drive vehicles), and fences as the minimum tools for managing Hawaiian wilderness (including prediction of volcanic eruptions and control of exotic species). Since these activities were agreed to by all interested parties as appropriate and necessary, the NPS proposed "special conditions" to recognize and allow those activities that might be considered to be in conflict with the Wilderness Act. During the E.I.S. process, testimony from environmental groups agreed with the need for these activities, and, in fact, often argued for the necessity of them. At least one national environmental group argued against the need for special conditions as they believed the Wilderness Act was sufficiently broad and flexible to allow scientific and management activities without special conditions (B. Harry, personal communication). They apparently felt the precedent of such conditions might limit similar activities in other wildernesses. Congress passed the Hawaiian wilderness legislation without the special provisions. The interpretation of this action by the then superintendent of Hawaii Volcanoes National

Park, based on his discussions with the Hawaiian Congressional delegation and others on the Hill, was that "they made a clear statement to all wilderness managers that science and native ecosystem preservation and restoration are fundamental to wilderness as contemplated under the 1964 Act" (Harry, personal communication).

Recognition of the importance of wilderness science is more recently evidenced by the fact that since 1993, the four federal wilderness management agencies (USDI Bureau of Land Management, U.S. Fish and Wildlife Service, USDA Forest Service and USDI National Park Service) and the U.S. Geological Survey's Biological Resources Division have cooperatively supported efforts to coordinate and facilitate wilderness research efforts. This is accomplished through support of the interagency Aldo Leopold Wilderness Research Institute, in Missoula, Montana; the only research group in the nation dedicated to developing the knowledge needed to improve management of wilderness and other natural areas (see www.wilderness.net/leopold).

Policies and Guidelines

Although the Wilderness Act and subsequent wilderness legislation clearly recognize the validity of science as an appropriate use of wilderness, they provide only broad philosophical guidance for establishing specific policy or guidelines for the conduct of science. For example, although the wilderness policies of all four wilderness management agencies endorse science as an appropriate use of wilderness (table 2), they emphasize restrictions to scientific use. Agency wilderness policies tend to focus on whether there is an alternative to conducting a study in wilderness (that is, can it be done elsewhere?), its impacts on wilderness values, whether it will interfere with recreational or other purposes of the area, and the importance of the study to management of the local area (see table 2 for examples of policy wording). There is little discussion in policy statements of the value of the information to be derived, what might be lost by doing the study elsewhere, or guidance on how to evaluate the "importance" or benefits of a proposed study. The policies are particularly quiet on the subject of benefits for broader regional or societal needs, and there is no mention of potential impacts of recreational or other permitted uses on scientific values. The overall impression is that science is not a preferred use and should be permitted only when absolutely necessary and when impacts can be avoided or minimized.

Table 2—Selected excerpts regarding research and scientific activities from the most recent wilderness policies of the four wilderness management agencies[a].

General policy

BLM[b]: "...provide opportunities for research and scientific activities...for study of natural environments and ecosystems" (1983).

FS "...provide appropriate opportunity for scientific studies that are dependent on a wilderness environment" (1990).

FWS "...provide opportunities for research, solitude, and recreation" (1986).

NPS "...will fully support the value of wilderness areas as natural outdoor laboratories" (1988).

Examples of policy constraints

BLM "provided that wilderness is essential to results of such research, and wilderness values would not be jeopardized."

FS "Do not allow the use of motorized equipment or mechanical transport unless the research is essential to meet minimum requirements for administration of the area as wilderness and cannot be done in another way."

FWS: "where...compatible with refuge objectives."

NPS: "The project will not interfere with recreational, scenic, or conservation purposes of the wilderness."

[a]As of the spring of 1999 the BLM, FS, and NPS were all actively revising their wilderness policies.
[b]BLM = Bureau of Land Management, FWS = Fish and Wildlife Service, FS = Forest Service, NPS = National Park Service.

Policy statements regarding what is appropriate and acceptable leave considerable latitude for interpretation. The result has been development of rather distinct policies and practices, as well as quite different management philosophies, between the four wilderness management agencies (Allin 1985). For example, although the wilderness policies of all four agencies emphasize the minimum requirement (or minimum tool) concept, they differ considerably in how they interpret what the "minimum" is. The Forest Service has developed a reputation of more strict interpretation of "minimum" and commonly prohibits some activities that the Department of Interior agencies are more likely to permit (Franklin 1981).

Agency guidelines are often so broad that local managers have discretion to make decisions on the appropriateness of many types of science activities, including changing decisions made by earlier administrators. This can lead to inconsistencies not only between agencies, but among units of the same agency. Large-scale studies that require work on multiple jurisdictions can be especially hampered by inconsistent requirements between adjacent areas. There is also a general lack of guidance regarding how proposals for scientific activities should be developed and what criteria will be used in their evaluation. Adding to the confusion faced by scientists proposing to work in wilderness, approval authority for research permits varies from state offices (BLM) to park superintendents (NPS) to districts (FS), often resting with individuals with little understanding of science.

Concern over how federal agencies evaluate science proposals (see, for example, Eichelberger and Sattler 1994) led to a 1995 National Academy of Sciences workshop to review the lack of a consistent policy for the conduct of science on protected public lands. This workshop resulted in a recommendation to conduct a National Academy review of the situation that has yet to be acted on.

In a recent survey of units in the four wilderness management agencies, I was able to identify only a few National Park Service examples of areas with detailed guidelines or formats for the proposal or approval of research projects in wilderness. Shenandoah and Grand Canyon National Parks are two areas that have developed guidelines to help potential investigators understand the concerns and constraints of wilderness managers. In both of these cases, the parks specifically encourage research and monitoring activities in wilderness, recognizing that some important work may require impacts, including the use of motorized devices. These parks provide for review of the benefits of proposed studies, including consideration of methodologies that specifically consider wilderness values. No examples were found of national forests, wildlife refuges or BLM districts with equivalent guidelines. Consistency in interpretation and application of laws, policies and guidelines would help those wishing to work in wilderness to better understand and comply with the applicable rules.

Managing Scientific Use

If science is to be recognized as a valid purpose and use of wilderness that, like recreation, is encouraged as long as potential benefits outweigh impacts, it will be necessary to overcome the perception that science is an intrusion that should only be permitted if essential to management of the local area. This perception is based in part on the tendency to apply Section 4(c) of the Wilderness Act, which prohibits motorized equipment, mechanical transport and structures and installations except under specified conditions, as a blanket restriction to all science. Reestablishing science as a primary use of wilderness will require renewed recognition of the value of wilderness to science, improved understanding and communication between wilderness managers and scientists, and an improved process for evaluating proposals for scientific activities. Such recognition could have profound effects on how wilderness is utilized to improve knowledge of our natural world and the impacts of human activities on it. It would emphasize the important role for wilderness in providing the understanding necessary to protect natural systems around the globe, as well as improve the information available to manage more impacted areas.

Graber (1988) suggested that scientific research should be permitted “for its own sake” as long as the resource costs are commensurate with those of other kinds of wilderness use, such as recreation. For example, he suggested approval of research activities with minimal or temporary impacts similar to those caused by recreation users. Thus, when considering proposals for research activities, the emphasis should not be on whether it is an appropriate use, but on how to maximize the benefits to be obtained and minimize or mitigate impacts caused by the use. Of course, it is important that scientists proposing to work in wilderness understand wilderness values and concerns about impacts to resources and values - much as recreational users are expected to understand and practice low-impact ethics. If science is treated as a valid and primary purpose of wilderness, scientists will be expected to comply with and support low-impact activities.

In the case of scientific activities with the potential for significant impacts, those impacts must be compared to the benefits to be derived. Again, if initial discussions focus on benefits and then proceed to options for minimizing and mitigating impacts, the chances of reaching agreement between managers and scientists are greatly improved. In the long term, this improved communication will assure the greatest benefit to wilderness, science and society. Only those projects with minimal benefits and significant impacts should be summarily rejected.

Zoning

One approach to encouraging greater scientific use of wilderness might involve managing different wildernesses, or portions of wildernesses, for different levels of scientific activity. Similar recommendations have been made for managing wildernesses for different use levels, impacts or types of management (Cole 1996). In the case of science, some wildernesses, or portions of wildernesses, could be managed primarily for their scientific value. In such cases, consideration should be given to whether recreation or other uses that might impact the scientific values of the areas should be restricted. This would be a different type of wilderness than has been typical in the United States, but one that is not inconsistent with protected area classifications in other parts of the world (Ostergren 1998).

Collaboration

Wilderness managers are often forced to make difficult decisions about contentious issues - from implementing use restrictions to the appropriateness of using prescribed fire to restore natural fire regimes. In many cases, these decisions require consideration of conflicting mandates, such as facilitating recreation use while managing for natural ecosystems. In today’s world, where interest groups are determined to protect their special causes, it is more important than ever that such decisions be based on solid science. To assure that the best possible science is available when needed, science and management must be brought into a partnership built on mutual understanding and trust. The best way to accomplish this is through open communication, including efforts to understand the context and constraints under which others operate. Improved understanding and communication between wilderness managers and scientists increase the likelihood that useful products will be obtained and impacts will be minimized.

A recently proposed geology project in Death Valley National Park in California exemplifies a situation where early communication brought about a compromise between the need to use wilderness for important science that is of little immediate value to the park (understanding of plate tectonics) and the sensitive wilderness values of the area. In this case, discussions between scientists and wilderness managers were able to identify a number of changes needed in the initial proposal to significantly reduce the impacts of the study without severely compromising the anticipated scientific benefits. The resulting compromise was a win-win situation for wilderness as well as scientists and managers (R. Anderson, personal communication). This contrasts sharply with the confrontation between the National Park Service and geologists proposing to study vulcanism at Katmai National Park in the early 1990s which ended with the scientists withdrawing their research application in frustration (see Eichelberger and Sattler 1994).

Guidelines

There is a clear need for both managers and scientists to have access to guidelines specific to the proposal, evaluation and conduct of scientific activities in wilderness. Such guidelines should help managers recognize and evaluate the benefits of science to wilderness as well as to larger conservation issues, while helping scientists better understand the constraints on managers and the basis for concern over the impacts science can have. Guidelines for managers should address the value of wilderness to science as well as the value of science to wilderness. They should emphasize that large, relatively undisturbed natural areas are increasingly important to the understanding of regional and global environmental problems. Since the scientific value of wilderness in the future is impossible to fully anticipate, it is especially important that today's managers recognize that the wilderness resource they are responsible for may hold keys to the understanding and future sustainability of regional and global environments. A proposed framework for evaluating scientific proposals (Landres, this proceedings) provides valuable guidance on how to think about the benefits as well as the impacts of scientific activities, including those benefits important beyond the immediate area.

Guidelines for scientists interested in working in wilderness must address the concerns of managing and protecting "untrammeled" ecosystems with "the imprint of man's work substantially unnoticeable." Such guidelines should detail concerns about impacts to ecosystem elements and processes, as well as to opportunities for "solitude or a primitive and unconfined type of recreation." They should specifically address the information required in an application for a research permit, including discussion of such issues as access to sites, ground disturbance, use of equipment and animal welfare. They should fully address options for minimizing or mitigating impacts. Table 3 itemizes a number of options for mitigating impacts of scientific activities. Guidelines for scientists should serve as principles of conduct, outlining what is and is not appropriate behavior in the conduct of wilderness science. Access to such information should help assure that proposals for work in wilderness are responsive to wilderness concerns, increase the chances of proposals being approved and, by so doing, avoid much of the acrimony that has accompanied past efforts of scientists to work in wilderness. Successful examples of such guidance include "Principles for the Conduct of Research in the Arctic" prepared by the Interagency Arctic Research Policy Committee of the National Science Foundation's Office of Polar Programs (IARPC 1992) and the Protocol on Environmental Protection, which governs activities in the Antarctic (National Research Council 1993).

As of the spring of 1999, the National Park Service is on the verge of adopting national guidelines and protocols for the application and approval of research and collecting permits (J. Bayless, personal communication). These guidelines itemize the factors to be considered in the evaluation of proposals; they provide the information that should be included in an application for a permit. Although the guidelines do not specifically address wilderness concerns, the factors addressed include many of the issues of greatest concern to wilderness managers: safety, access to study sites, use of motorized or other equipment, use of chemicals, ground disturbance and animal welfare. They also address the need to adhere to "minimum requirement" and "minimum tool" concepts if the activities will be conducted in areas administered as designated, proposed or potential wilderness. Such guidance represents a major advance in improving communication with the scientific community.

Table 3—Options for mitigating impacts of science.

1. Siting of equipment or activities to minimize visual intrusion
2. Timing of activities to avoid high visitor use periods
3. Use of primitive tools
4. Nondestructive sampling
5. Capitalize on education opportunities

Conclusions

It is clear that science is both a statutory purpose of wilderness and critical to the long-term protection of wilderness. It will be impossible to assure the long-term preservation of wilderness without a thorough understanding of wilderness resources and values, including public perceptions and desires, and ecosystem elements and processes, as well as threats to those resources and values. This requires the protection of scientific values of wilderness, as well as support for and accommodation of the use of wilderness for science. Given this understanding, I argue that the conduct of science should be viewed as every bit as appropriate and desirable as other statutory uses of wilderness. Like recreation, it should be permitted to the extent that wilderness resources and values are not unduly compromised. This interpretation appears to be consistent with the thinking of Howard Zahniser, the principal architect of the Wilderness Act, as well the understanding of legislative intent held by principal figures involved in the 1970s Hawaiian wilderness proposals. However, this recognition does not mean that scientists should be given carte blanche to conduct scientific activities where, when and how they propose. It is critical that research and other proposed scientific activities in wilderness be carefully evaluated to assure that the benefits outweigh the impacts.

Improved understanding and communication between wilderness managers and scientists are essential to development of a science-friendly environment in which the best possible science is conducted with the minimum possible impact. To be fully effective, this communication must begin early in the project conceptualization and proposal process and continue throughout the life of the project, including the application of results to policy or practice. Federal wilderness management agencies need to more explicitly articulate their recognition and support of the scientific value and use of wilderness in their policies, guidelines and practices. Scientists must pay attention to and try to understand the concerns and constraints of wilderness managers, as well as strive to reduce or mitigate the impacts of proposed activities. Managers and scientists should work together to develop guidelines to help both groups better articulate their interests and needs in a wilderness context. Guidelines for managers should clarify the appropriateness of various scientific activities and provide guidance on how to evaluate proposals. Guidelines for scientists should clarify the concerns of wilderness managers, articulate the issues that need to be addressed in a proposal, and outline principles of conduct for scientific activities in wilderness. Such cooperation will help us think about wilderness and science as mutually supportive and, in so doing, help assure the long-term preservation of wilderness.

References

Adams, C. C. 1929. The importance of preserving wilderness conditions. New York State Museum Bulletin 279:37-44.

Allin, C.W. 1985. Hidden agendas in wilderness management. Parks and Recreation 20(5):62-65.

Anderson, Richard. 1999. [Personal communication]. March 25. Death Valley, CA. National Park Service, Death Valley National Park.

Bayless, Jonathon. 1999. [Personal communication]. March 25. San Francisco, CA. National Park Service, Western Regional Office.

Brower, D. 1960. The Meaning of Wilderness to Science. Sierra Club, San Francisco, CA. 129 p.

Cain, S. A. 1960. Ecological islands as natural laboratories. Pp. 18-31 in Brower, D. (ed.) The Meaning of Wilderness to Science. Sierra Club, San Francisco, CA.

Christensen, N. L. 1988. Succession and natural disturbance: paradigms, problems, and preservation of natural ecosystems. Pp. 62-86 in Agee, J. K. and D. R. Johnson (eds.) Ecosystem Management for Parks and Wilderness. University of Washington Press, Seattle, WA.

Christensen, N. L.; A.M. Bartuska; J.H. Brown; S. Carpenter; C. D'Antonio; R. Francis; J.F. Franklin; J.A. MacMahon; R.F. Noss; D.J. Parsons; C.H. Peterson M.G. Turner; R.G. Woodmansee. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. Ecological Applications 6(3):665-691.

Cole, D. N. 1996. Ecological manipulation in wilderness - an emerging management dilemma. International Journal of Wilderness 2(1):15-19.

Cole, D. N. and P. B. Landres. 1996. Threats to wilderness ecosystems: impacts and research needs. Ecological Applications 6(1):168-184.

Eichelberger, J. and A. Sattler. 1994. Conflict of values necessitates public lands research policy. EOS, Transactions, American Geophysical Union 75(43):505-508.

Franklin, J. F. 1981. Wilderness for baseline ecosystem studies. Pp. 37-48 in Proceedings XVII IUFRO World Congress, Division 1. Forestry and Forest Products Research Institute. Ibaraki, Japan.

Franklin, J. F. 1987. Scientific use of wilderness. Pp. 42-46 in Lucas, R. C. (Compiler), Proceedings - National Wilderness Research Conference: issues, state-of-knowledge, future directions. USDA Forest Service, General Tech. Report INT-220. Ogden, UT.

Graber, D. M. 1988. The role of research in wilderness. The George Wright Forum. 5(4):55-59.

Graber, D. M. 1995. Resolute biocentrism: managing for wildness in national parks. Pp. 123-135 in Soule, M. E. and G. Lease (eds.) Nature and Reality: Critiques of Postmodernism Deconstruction. Island Press, Washington, D.C.

Harry, B. 1999. [Personal communication]. May 28, letter to David J. Parsons. Written from USDI National Park Service, Honolulu, Hawaii.

IARPC (Interagency Arctic Research Policy Committee). 1992. Principles for the Conduct of Research in the Arctic. Arctic Research in the United States 6:78-79.

Landres, P.B. [In press]. A framework for evaluating proposals for scientific activities in wilderness. In: McCool, Stephen F.; Cole, David N.; Borrie, William T.; O'Loughlin, Jennifer, comps. 2000. Wilderness science in a time of change conference—Volume 3: Wilderness as a place for scientific inquiry; 1999 May 23-27; Missoula, MT. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Leopold, A. 1921. The wilderness and its place in forest recreational policy. Journal of Forestry 19(7):718-721.

Leopold, A. 1941. Wilderness as a land laboratory. Living Wilderness 6:3.

Leopold, L. B. 1960. Ecological systems and the water resource. Pp. 32-45 in Brower, D. (ed.) The Meaning of Wilderness to Science. Sierra Club, San Francisco, CA.

Lucas, R. C. 1986. Proceedings—national wilderness research conference: current research. USDA Forest Service, General Tech. Report INT-220. Ogden, UT. 553 p.

Lucas, R. C. 1987. Proceedings—national wilderness research conference: issues, state-of-knowledge, future directions. USDA Forest Service, General Tech. Report INT-220. Ogden, UT. 369 p.

Nash, R. 1982. Wilderness and the American Mind. 3rd edition. Yale University Press, New Haven, CN. 425 p.

National Research Council. 1992. Science and the National Parks. National Academy Press, Washington, D.C. 122p.

National Research Council. 1993. Science and Stewardship in the Antarctic. National Academy Press, Washington, D.C. 107 p.

Ostergren, D. 1998. System in peril—a case study of six Siberian nature preserves. International Journal of Wilderness 4(3):12-17.

Parsons, D. J. 1998. Scientific activities in wilderness. International Journal of Wilderness 4(1):10-13.

Parsons, D. J. and D. M. Graber. 1991. Horses, helicopters and hi-tech: managing science in wilderness. Pp. 90-94 in Reed, P. C. (Compiler), Preparing to manage wilderness in the 21st Century. USDA Gen. Tech. Rep. SE-66.

Sinclair, A.R.E. 1998. Natural regulation of ecosystems in protected areas as ecological baselines. Wildlife Society Bulletin 26(3):399-409.

Sumner, F. B. 1921. The responsibility of the biologist in the matter of preserving natural conditions. Science 54:39-43.

Sumner, E. L. 1942. The biology of wilderness protection. Sierra Club Bulletin 27(8):14-22.

U.S. Congress. 1963. Senate Report 109 on S.4 of the Senate Committee on Interior and Insular Affairs. 88th Congress. 1st session. April 3, 1963.

U.S. Congress. 1964. Congressional Record. Vol 110, Part 13. 88th Congress 2nd session. July 30, 1964.